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ROBERT IRWIN REES, PRESIDENT OF THE SOCIETY

Robert I. Rees was born in Houghton, Michigan. He received his B.S. and E.M. at Michigan College of Mining and Technology, Houghton, Michigan; and attended Harvard University for one year, and New York Law School, one year.

He served through the Spanish-American War and the Philippine Insurrection, receiving commission as 2d Lieutenant in Regular Army, October 1, 1899, while serving in the Philippines.

Distinguished Graduate, Army School of the Line, 1913; graduate, Army Staff College, 1914; graduate, Army War College, 1923. Detailed as member of General Staff Corps at the beginning of the World War and served in War Plans, Executive, and Operations Divisions, General Staff, Washington, D. C. Appointed Chairman of the Committee on Education and Special Training, January, 1918, in charge of the military and technical training of technicians and mechanics for the Army in Educational Institutions. This organization later developed into the Students' Army Training Corps with the added objective of preparing college students inducted into the service for commissions in the Army.

Arrived in France, December, 1918, and was assigned to General Pershing's Staff at G. H. Q., Chaumont, in charge of all educational work in A. E. F., 287,000 men regularly attended the schools and the university established, with 1,600,000 more reached by lecture courses and institutes. Returned to Washington and was reassigned to the War Plans Division as Chief of the Education and Recreation Branch.

During the World War President Rees was advanced through the grades from Captain to Brigadier General. Awarded the D. S. M., February, 1919, "for exceptionally meritorious and conspicuous service" to the government; made Oficier, Legion d'Honneur, April 30, 1919.

ROBERT IRWIN REES
President of the Society

General Rees was a member of the War Department General Staff, Operations and Training Division in charge of the Reserve Officers' Training Corps; also War Department member of the Federal Council of Citizenship Training and member of National Research Council at time of resignation in February, 1924, to become Assistant Vice President, American Telephone and Telegraph Company, in the Department of Personnel and Public Relations. Responsible for the employment and training of college students for the Bell System, and for the development of general educational activities.

He has been a member of the Society since 1924.

THE CURRICULUM AT ECOLE POLYTECHNIQUE

By AUGUSTIN FRIGON, Director

Ecole Polytechnique of Montreal was founded in 1873, and since that time it has endeavored to give its students a general education in applied sciences. The degree of "Civil Engineer" is given to those who have satisfactorily gone through the regular five year course. It must be understood, however, that in this case the title "Civil Engineer" is used in opposition to that of "Military Engineer" as it is the practice in some European countries. It does not correspond to the branch of "Civil Engineering" as known on this continent, but rather to the broader field of "General Engineering." To conform to the American practice, however, the graduates of Ecole Polytechnique also receive the degree of B.A.Sc. This gives them a more appropriate standing when they apply for positions. It is hoped that when the public of this district, which has been used to the title "Civil Engineer" as given by this School for the last fifty-six years, is better prepared, a change will be made and only the degree of B.A.Sc. will be granted. Special post-graduate courses are available to those who have already obtained the B.A.Sc. given by the School. In 1917 a special program for specialists in chemical engineering was offered as an option to the students of the two last years of the regular course, but according to a recent decision of the Board of the School, this has been abolished.

An exclusive feature about Ecole Polytechnique is that French is the only language used in that School. The students must therefore possess a thorough working knowledge of that language to be able to follow the course. However, most of the textbooks used in the applied science course are in English edited either in England, in United States or in Canada. This also means that the students must be bilingual.

The use of English texts is necessary in order to teach the engineering methods used in Canada. Besides they give to the students an excellent opportunity to perfect themselves in that language which they all know to a certain degree before they enter the School.

The course is at present of five years' duration. Graduates of the classic colleges of the Province of Quebec, with a "Bachelor of Arts" degree, are admitted in the first year without examination, those of secondary schools (tenth grade) of the Province of Quebec are admitted after they have passed an examination in mathematics, all others must pass a full matriculation examination before they are admitted.

During the first year of the course a brief review is made in algebra, geometry, trigonometry and of elementary physics. The regular courses in chemistry, analytic and descriptive geometry and drafting also start in this year.

During the second year a fresh start is made in more advanced physics, the course in analytic geometry is concluded, descriptive geometry is completed. Work in calculus, in applied mechanics and surveying is begun.

Physics, chemistry, calculus, surveying, applied mechanics have been covered by the end of the third year. At that time mineralogy, geology, resistance of materials, French redaction, mining, mechanism are well under way.

In the fourth year are started the more practical courses such as electrical engineering, Thermodynamics, hydraulics, metallurgy, reinforced concrete, structural design, civil engineering, heating and ventilation, law, etc.

The program of the fifth year includes bridge designs, hydraulic machinery, civil engineering, railroad economics, architecture, finance, building construction, highway and structural engineering, dam and retaining wall design and other courses which had been started in the earlier stage of the course.

Besides these, the curriculum also includes about one hundred and ten hours of machine shop work, one month field work in surveying, numerous visits to industries, many applied science graphic problems done in the drafting room.

At the end of the fifth year each student is expected to submit a personal study on some engineering question, accompanied with a certain number of drawings. In this work which occupies all his spare time in the fifth year and even a part of the fourth year, the student is supposed to study one particular problem in whichever branch of engineering into which he expects to specialize once he has left the school. These are not merely graphic studies but must include a general description of the subject quite often including the economic aspect, and presented in such a way as to prove that the student is fully prepared to start in his engineering career. Here is a list of the problems which were submitted this year.

Steam heating system for a residential district.
Filled spandrel reinforced concrete arch bridge.
Central station to supply the required steam for heating 1,000 duplex houses.
Five-ton plant for treating copper ore.
Incineration plant for the City of Montreal.
Water supply system for a small town.
Mooring tower for dirigibles.
Heating and ventilating system for a church.
Treatment of a quartz ore by the cyanide process.
Retaining dam for a water reservoir.
Flood lighting of one of the Montreal public squares.
Design of an office building for an industrial plant.
Structural design of an airplane wing.
Long distance telephony by means of carrying current.
Study of different wood drying processes.
Steel tower for a 750 ft. span of a transmission line.

Very little research has been done either by the staff or by the students of Ecole Polytechnique. All the activities of the School are concentrated on teaching. The laboratories are well equipped, but for teaching purposes only. They comprise a physics laboratory, a general chemical laboratory and one for applied chemistry. There is also a special laboratory for studying inorganic matters and for standardized test-

ing of various materials such as asphalts, oils, etc. An electrical engineering and an electrical standardizing laboratory; a full equipment for testing materials with a department for testing materials entering in the construction of highways. There is at present under construction a hydraulic laboratory and a medium size gymnasium. The school also has a very good collection of Canadian specimens in its mineralogy and geological museum. The library which has been completely renovated during the last few years is composed of approximately 12,000 volumes in pure and applied science, about 8,000 fully classified catalogues and some 400 periodicals.

It will be noticed that although the primary object of the course is to give a general formation in engineering, that there is a slight tendency in the curriculum to emphasize the "civil" branch of engineering; this is due to the fact that a great many of the graduates of the school have been engaged in that line in the development of the Province of Quebec, but nevertheless the other departments of the curriculum are sufficiently developed to allow any graduate to specialize in any branch without difficulty. One of the arguments in favor of keeping this curriculum of general engineering studies is the fact that all the graduates of the school without a single exception, whether they have been working in the Province of Quebec, in other parts of Canada, in United States or abroad, are all in favor of the present system, and have advised the authorities of the school on many different occasions not to depart from that method. It must be admitted that with the increasing quantity of fundamentals which are required by the engineer, it is getting more and more difficult to fit in a five year course, including only one hundred and thirty-six weeks of actual class work, all the essentials of such a curriculum. In order to remedy to this difficulty it is being considered to require of the students entering this school that they know most of the mathematics which are now on the first year program. Only one thing is sure, and that is that the Ecole Polytechnique will continue to try to give a general education in fundamentals of engineering and will leave to

its graduates the liberty to specialize in whatever branch they may choose once they are in actual practice; the experience being that they can very readily do so within a short period after graduation while benefitting the rest of their professional life of the sound formation they have received.

SUCCESS IN COLLEGE AND BUSINESS *

By DONALD S. BRIDGMAN

American Telephone and Telegraph Company

Editorial Note

The members of the Society for the Promotion of Engineering Education will recall that at the Chapel Hill Meeting in 1928, Colonel Rees presented a preliminary report of the studies in progress in the Bell System, on college graduates in that organization, showing the relation between the experiences of college life to future progress in industry. Since that time, Mr. D. S. Bridgman has made a thorough analysis of the information received, the results of which appear in this paper entitled, "Success in College and Business."

Introduction

The prediction of success or failure in business for men entering it on graduation from college is an extremely hazardous undertaking. The interactions of all the factors influencing these men make it a problem of the most complex sort. One major difficulty arises from the very different environments faced by them in college and after graduation. If, however, the colleges are not failing seriously in at least one of their major purposes, men who are successful in them should be more likely to succeed later.

But college success is not measured by a single yardstick. Some men are high-rank scholars, others are editors of college magazines, managers of teams, athletes. Still others satisfactorily complete the requirements for the degree while overcoming the most severe financial handicaps. Are any of these accomplishments more indicative than others of business success or does none of them give a clue to it?

* Paper delivered at Atlantic City, February 22, 1930, before the Joint Meeting of organizations interested in personnel and vocational guidance under the auspices of the Personnel Research Federation, and Published in the June, 1930, Personnel Journal.

To answer such questions as these was one purpose of the Bell System in establishing five years ago a centralized record of all college graduates in its companies. Such a record would be extremely useful for administrative purposes. It would permit the study of salary progress of graduates in the several companies and departments. From it, studies of their losses could be made. Its value would be unquestionable if it also assisted in improving the means by which the right men for the telephone business could be selected.

In employing college graduates some stress had been placed on their scholarship, on their participation in campus activities, and on their earnings in college. There were, however, no definite data indicating that these were indices of success in the telephone business. To make quantitative studies of the relations between these factors and such success seemed distinctly important. Beyond this, it was hoped that such studies would be of interest and possible value to education itself.

The Bell System Companies together are probably the largest single employers of college graduates in the country. It, therefore, had a rather unique opportunity to study the progress of graduates in its employ in relation to their achievements of various kinds in college. A centralized record was accordingly set up in 1925 in the personnel department of the American Telephone and Telegraph Company under the direction of Mr. E. K. Hall. Soon afterward it seemed worth while to attempt an immediate study of the relation between college scholarship and success in the Bell System.

Those colleges from which a number of graduates had come to the System were, therefore, asked to furnish their scholarship records. From them, such a study was carried out and its results were published in the article "Does Business Want Scholars?" by W. S. Gifford, President of the American Telephone and Telegraph Company in *Harper's Magazine* for May, 1928. This article did arouse a considerable amount of interest among educational people. Spontaneous requests were received for about 25,000 reprints of it and these were distributed.

It is likely, however, that the article enhanced the Bell System's popularity with college authorities somewhat more than with college students. In fact, there was one case where a boy had been in some minor scholastic difficulty. When the telephone representatives visited the campus one of them gave this boy a copy of Mr. Gifford's article. He said, "Thank you, but do I have to read this? You see last week-end I was at home and father gave me one of these and then Tuesday I was talking with the dean and he gave me one also."

The interest aroused by this article was so great that it seemed worth while to undertake other studies immediately based on records of campus activities, student earnings in college and other factors which might be readily available. Information concerning these factors on a substantial number of men has therefore been obtained and the present paper reports this study in full.

PART I

General Problems and Study of Two Individual Factors

The Methods Employed

The first general problem to be considered in developing such a study is that of method which naturally breaks down into a number of minor problems. The first of these involves the criterion of success to be used. It was decided to use salary as compared with years since graduation as this criterion. It is recognized that this is not a perfect measure of success, but in an organization like the Bell System with consistent salary standards it is likely to parallel success very closely.

Although Bell System salary standards throughout the country are consistent, they are not uniform. It was therefore necessary to compensate for different standards due to economic conditions in different parts of the country. This was done by finding the medians for all the men covered by geographic areas and weighting individual salaries to a common base in accordance with the differences thus found. It

was also felt that salary should be measured against years since graduation rather than years of service in the Bell System. All cases of men who had spent less than half of their working life in the Bell System were excluded entirely, however, and of those included about 60 per cent entered its work during the year in which they completed college.

A second problem arises from differing college standards, different sizes of institutions, and similar variations. These difficulties were avoided to some extent in the study of scholarship by relating men to their own groups. The colleges were not asked whether a man had an average record of 90 or 70 but whether he had been in the first tenth of his class (as such a group would distinguish the exceptional men) and if not, whether he had been in the first third, middle third or lowest third. In other words, was he distinctly above average, average or below average? In a sense this ignores the differing standards of institutions except in recognizing that due to them a larger number of ranks would probably be artificial.

For campus activities a definitely relative scale was impracticable. On the other hand, the competitive nature of campus activities makes any record of them somewhat relative. In the study, therefore, achievement in campus activities was determined on the basis of actual offices, team membership, etc., which each man held. Consistency of judgment in this classification was insured by making it from the year books of the institutions almost entirely by a single person using objective standards previously set up.

In the case of earnings of college expenses an absolute proportion of expenses earned was determined by a questionnaire sent to the men for whom we already had scholarship and campus activity information. From this questionnaire a very high percentage of return was received. The replies to it undoubtedly present a thoroughly valid picture of the degree to which the men covered earned their way through college as a result of work carried on during the four years of their college course during both term time and vacation periods.

The final and most difficult problem of method was that of

expressing any relationships which might be found between success and college achievement. To present such a study without a single sigma or, worse, even a correlation coefficient is extremely hazardous. Good statisticians, however, agree that it is not illogical to avoid this usual method of expressing relationships because of the small number of ranks available without unwarranted artificialities and because with salary data that method is likely to give rather unreliable results due to the large variations from the average salary in a few cases. For these reasons a much less technical method of analysis has been used.

First of all median salaries were computed for the various periods after graduation, both for each of the entire groups studied and for the groups selected by scholarship rank, campus achievement, etc. The median salary, or the salary of the middle man of a group, rather than the average was used as it is less affected by a few extreme cases. This method was useful only where the selected groups were fairly large and medians could rather accurately be determined. In the case of smaller selected groups, their salary distribution was compared with the salary distribution of the entire group from which they were taken.

General Validity of Results

Before attempting to show the actual results obtained, some discussion of their general validity is probably worth while. Of course, these results are valid for the Bell System only. They must be interpreted in the light of the qualities which are likely to make for success in it. Quite different results might very well be obtained for a different type of business. In the Bell System, as in other businesses, success does often require leadership of large groups of men and women or the ability to make effective public contacts. Emphasis however, is placed in it on the ability to develop careful methods, to analyze thoroughly the results obtained rather than on high pressure salesmanship or the intuitive grasp of immediate situations.

The validity of the results depends also on the size of the

groups studied. The scholarship study was made first with about 1,000 cases, then for about 1,500 and finally for about 3,800. Almost identical results were obtained with each of these groups. All of the main groups, therefore, seem large enough to give reliable results. About some of the highly selected groups there is considerably more question.

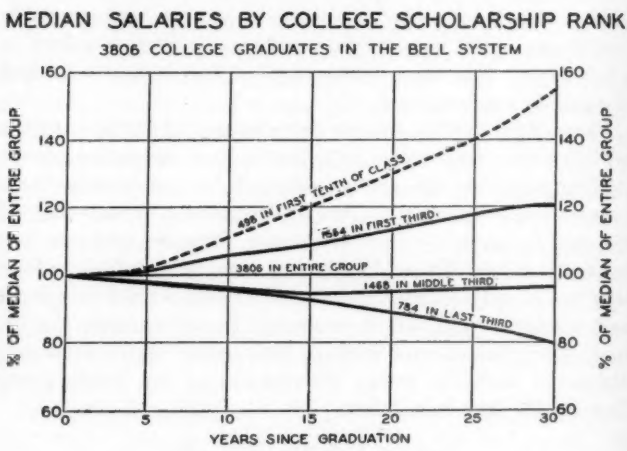

CHART 1.

The validity of the results may also be criticized because they are drawn from the study of a group which has been specially selected for a single industry and has remained in that industry. The influence of selection, however, may cause relationships which are less striking than those for a random group. As high scholarship and substantial campus achievement have been used as criteria of selection, when either or both are absent, other compensating qualifications have been demanded.

The selective effect of losses cannot, however, be measured at all accurately. This is partly because most of these losses occur during the first year or two before there is available objective evidence in terms of salary concerning the probable

success or failure of the men in question. It is partly due also to the fact that there is no record of men who left more than five years ago. The distributions of the older and younger men at least by scholarship are quite comparable, however, and, among the more recent classes, the distributions by scholarship and other campus achievements of the men who have left and of those who remain are about equal. The causes of separation thus seem not at all closely related to these college factors. Such phenomena, therefore, as the retention of high scholarship men doing well and the loss of those doing poorly or the loss of low scholarship men doing well and the retention of those doing poorly have probably affected the results very little.

Summary of Study of Scholarship

With this general discussion as a basis, it now seems feasible to go directly to the charts which illustrate the results obtained from these studies. The first chart "Median Salaries by College Scholarship Rank" of 3,806 graduates in the Bell System is taken directly from Mr. Gifford's article in Harpers. In this chart the 100 per cent horizontal line represents the median of the entire group studied in terms of the years since graduation. The top line represents the median of 498 men who were in the first tenth of their classes, the next one that of 1,554 in the first third of their classes, etc. It is interesting to note that this group is somewhat better than a cross section of those classes. About 14 per cent of the men came from the first tenth of their classes, about 40 per cent from the first and middle thirds and only about 20 per cent from the last third.

Fifteen years after graduation the median of the first tenth man is 20 per cent above that for the whole group, 25 years after graduation it is 40 per cent and 30 years after graduation it is nearly 60 per cent. The median of the first third rises steadily but rather slowly and only approaches 20 per cent above the entire group median at 25 years after graduation, and is only slightly above it at 30 years after. The median of the middle third is somewhat below the median of

the whole group and that of the last third falls rather steadily until at 30 years after graduation it is only 80 per cent of that of the whole group.

The Influence of Campus Achievement

Chart 2 shows the median salaries by campus achievement groups. In this case the men studied were classified into three groups, those with substantial campus achievement, those with some achievement and those with no achievement.

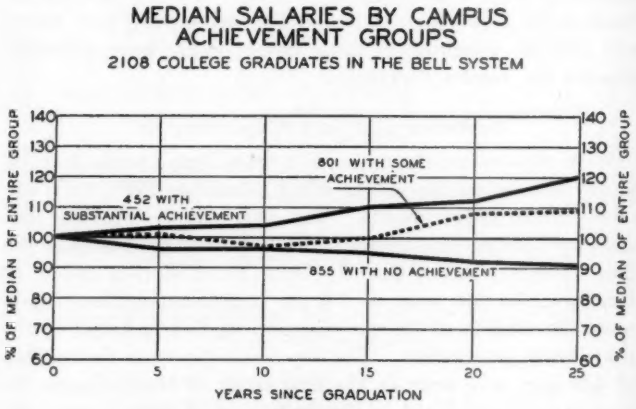

CHART 2.

Some achievement in this classification indicates a member of the editorial board of a magazine, the manager of a minor team or magazine, a minor class officer or the member of a social fraternity, the member of a minor athletic team or of a major varsity squad, or finally a member of a dramatic or musical club.

Substantial achievement indicates the editor-in-chief of a magazine, the winner of an important oratorical contest or member of an important debating team, the manager of a major team or important student newspaper, a major class officer or member of an honorary senior society, or the leader of a dramatic or musical club. It also indicates some

achievement in two or more fields, not including fraternity membership. That is, a man who was on the board of a paper and on a minor team would be regarded as having won substantial campus achievement but a man who was on the board of a magazine and was merely a fraternity member in addi-

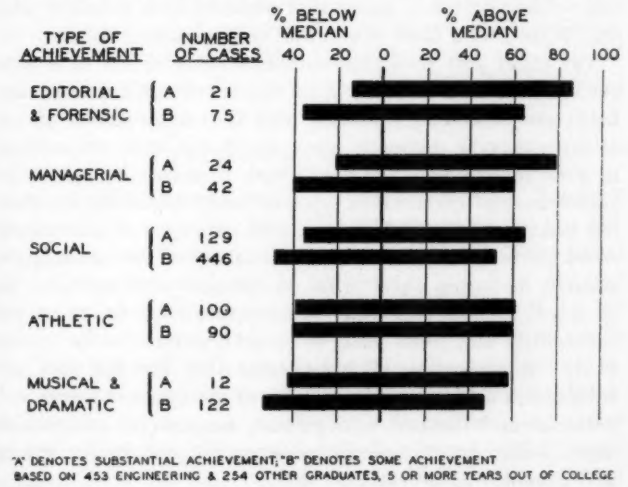

CHART 3.

tion would not be so regarded. On the basis of this classification we find that 21 per cent of the 2,108 men covered by this study were classified as winners of substantial campus achievement, 38 per cent as winners of some campus achievement and 41 per cent as those with no campus achievement.

The medians in this chart have been carried only to 25 years after graduation as there were not enough cases after that point to warrant drawing them further. The median for men with substantial achievement reaches 20 per cent above that for the whole group at the 25 year point. That is about

what the median for the first third men in scholarship did. It must be remembered in comparing them, however, that this group comprises only 21 per cent of the entire group studied whereas the first third men in scholarship made up about 40 per cent of that entire group studied. Furthermore, the median for the first tenth men in scholarship comprising 14 per cent of the men studied, at 25 years after graduation is 40 per cent above that for the whole group. On the basis of this evidence alone it seems that scholarship is a rather more significant factor than substantial campus achievement.

The chart just presented combines achievement in a number of different fields. It is, of course, recognized that these fields are exceedingly diverse and that achievement in one of them may be distinctly more significant than achievement in some other one. The next chart, therefore, compares the significance of the various types of achievement by determining what proportion of the men with each type of achievement stood above and below the median salary of the entire group studied including those with no campus achievement. The A and B bars on this chart stand respectively for those with substantial and those with some achievement in the various fields. Examination of it indicates that for the men with substantial achievement the order of significance seems to be editorial and forensic achievement, managerial achievement, social achievement, athletic achievement and finally musical and dramatic achievement.

Some of these groups are distinctly small but the general rank seems to be rather well borne out by the fact that the B bars also range in about the same order. The exceptions to this are in the case of social and athletic achievement but that seems to be due to the nature of those particular activities. The B bar under social achievement is largely made up of those who are merely fraternity members. The two bars for athletic achievement indicate that while it is distinctly a favorable factor, it makes relatively little difference whether a man is a member of a major team or merely a minor team or varsity squad. The only type of activity which seems to be at all unfavorable is musical and dramatic achievement with-

out the achievement of definite leadership in it, but even here the degree of negative correlation is distinctly small.

In view of the results obtained in the study of scholarship it is distinctly interesting that the most significant type of achievement by this analysis seems to be a rather intellectual type, namely literary and forensic achievement. With outstanding achievement in this field, good scholarship is also usually present; with some achievement in it, somewhat better than average scholarship. The managers, on the other hand, particularly those of major activities, are rather below average in scholarship. On the whole, however, the type of campus achievement does not seem to be very closely related to scholarship.

The Influence of Curricula

One interesting point should be mentioned here. The type of curriculum seems to have no influence at all on the significance of scholarship. Almost identical results were found for men who had graduated in engineering and those who had graduated in other courses, mainly arts and science. In the case of campus achievement, however, this was found to be true. Substantial achievement was rather less significant, although a favorable factor, for men of engineering training, than it was for men of training in arts and science. Some campus achievement, on the other hand, was rather more significant for the men of engineering training than it was for the men in arts and science. It may well be that the engineering student who spends a great deal of time in extra curricular activities may thereby neglect his college work to such an extent that it affects his future success or, on the other hand, it may be that men who are not particularly interested in their engineering work compensate for that by undue activity in other fields.

PART II

The General Study of Several Factors

Introduction

The material presented so far deals with single factors, and it has been based on somewhat different groups. It now seems useful to take a single group for which are known the scholarship, extra curricular achievement, degree of college earnings and other facts about the men and compare the effects of single factors and of combinations of factors in this group. For such a group it was possible to obtain data on 1,310 cases, of whom all the men were four or more years out of college. At this point there seems to be sufficient spread in the salaries received to warrant beginning the study there. Below it the spread is rather narrow and salary differences may be based on somewhat temporary factors.

In the study of this group to the three primary elements of college life, namely study, campus activities and, where necessary, the earnings of one's expenses, two others which were readily available were added, the age at graduation and time of employment in the Bell System relative to date of graduation. The latter, of course, is not strictly a college factor but it does bring out one point which seems worth making.

Inter-Relations of Factors

Of course, to estimate the significance of these several factors it must be known whether or not they are independent of one another, whether the same men are both good scholars and outstanding men on the campus, or are distinctly not the same men and whether men earning a large part of their way through college are therefore unable to take part in campus activities.

Chart 4 illustrates a method of analyzing these relationships. The first set of bars studies the distribution by extra curricular achievement of those men who have earned a large part of their way through college and those who have earned a small part or none of it. It seems to indicate a very slight inter-

relationship between these two factors in that a slightly smaller proportion than normal of the men who earned over two thirds of their way through college were able to win

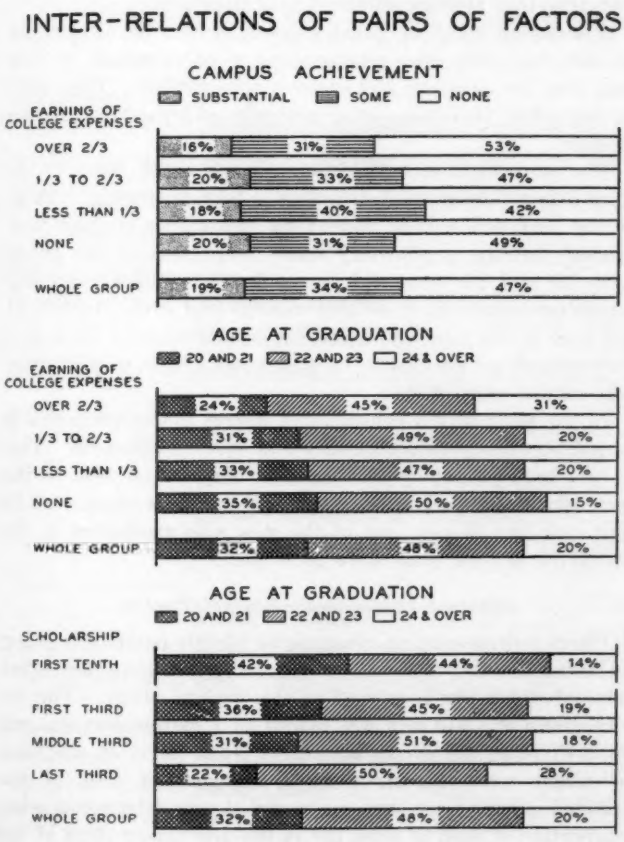

CHART 4.

substantial achievement in campus activities. On the whole, however, these two factors seem suprisingly independent. This, of course, may be due to the fact that in some cases men

earn their way through college by campus activities. For example, the editor or business manager of a paper may have made money in that way. In other cases it may even have been true that athletes obtained paid sinecures.

In studying all of the other pairs of factors not illustrated on the chart the inter-relationships were found to be less than that for earnings and campus achievement. They may be regarded, therefore, as practically independent of one another.

The two remaining sets of bars on this chart, however, do show a fairly substantial degree of inter-relationship. Thus, of the men who earned more than two thirds of their way through college, a relatively small proportion of the group were 20 and 21 years old on graduation and a relatively larger proportion of those men were 24 and over. In fact 31 per cent of the men who earned over two-thirds of their way through college were 24 or over and but 15 per cent of those who earned none of it.

In the same way a considerable degree of inter-relation is found between good scholarship and early graduation. This is best brought out by the fact that only 14 per cent of the men who graduated in the first tenth of their class were 24 and over but 28 per cent of the men who graduated in the last third of their class were 24 or over.

Relative Influence of Several Factors

Chart 5 demonstrates the analysis of this particular group in terms of the five factors studied. It shows the other method which has been used in this general study. The entire group of 1,310 men was placed on a scatter diagram and lines dividing the group into three equal parts on the basis of salary were drawn. Scatter diagrams of each of the selected groups were then made and it was determined what proportion of each of them lay in the first salary third of the whole group, what proportion in the second third, and what proportion in the last third.

Thus, it is found that 53 per cent of the 185 men of this group who were in the first tenth in scholarship now are in

the first third in salary, and only 18 per cent are in the last third in salary. 45 per cent of the men in the first third in

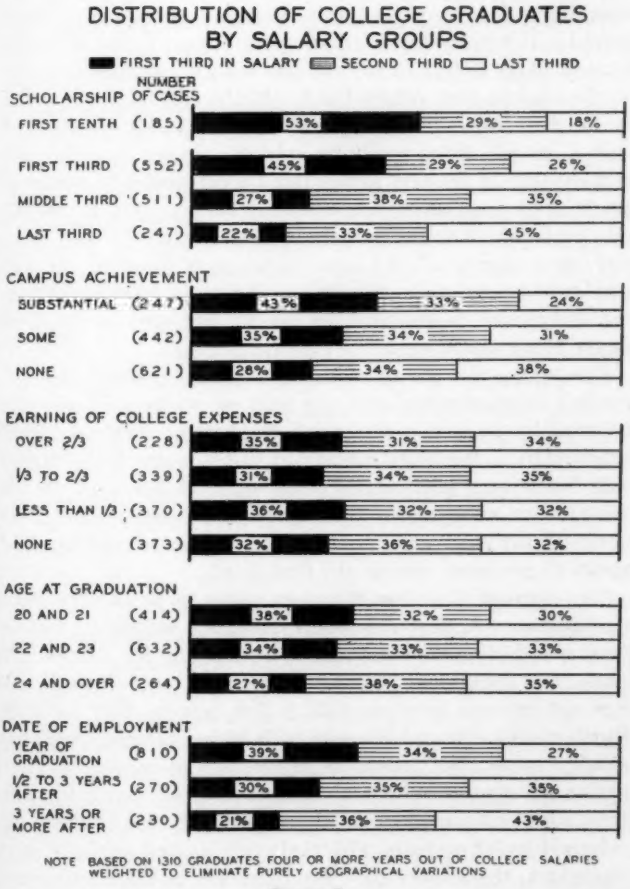
DISTRIBUTION OF COLLEGE GRADUATES
BY SALARY GROUPS
FIRST THIRD IN SALARY
SECOND THIRD
LAST THIRD
NUMBER OF CASES
SCHOLARSHIP
FIRST TENTH (185) 53% 29% 18%
FIRST THIRD (552) 45% 29% 26%
MIDDLE THIRD (511) 27% 38% 35%
LAST THIRD (247) 22% 33% 45%
CAMPUS ACHIEVEMENT
SUBSTANTIAL (247) 43% 33% 24%
SOME (442) 35% 34% 31%
NONE (621) 28% 34% 38%
EARNING OF COLLEGE EXPENSES
OVER 2/3 (228) 35% 31% 34%
1/3 TO 2/3 (339) 31% 34% 35%
LESS THAN 1/3 (370) 36% 32% 32%
NONE (373) 32% 36% 32%
AGE AT GRADUATION
20 AND 21 (414) 38% 32% 30%
22 AND 23 (632) 34% 33% 33%
24 AND OVER (264) 27% 38% 35%
DATE OF EMPLOYMENT
YEAR OF GRADUATION (810) 39% 34% 27%
1/2 TO 3 YEARS AFTER (270) 30% 35% 35%
3 YEARS OR MORE AFTER (230) 21% 36% 43%
NOTE BASED ON 1310 GRADUATES FOUR OR MORE YEARS OUT OF COLLEGE SALARIES WEIGHTED TO ELIMINATE PURELY GEOGRAPHICAL VARIATIONS

CHART 5.

scholarship were in the first third in salary and 27 per cent in the last third and finally for the last third in scholarship

22 per cent are in the first salary third and 45 per cent in the last third. It is important to discover just what chance there is that the distributions here found are due to errors of sampling. The chance of this, however, seems very small indeed. If scholarship were not a significant factor it would be most likely to find in any random sample about 33 per cent of the men in each salary third. If the 552 men who stood in the first third in their classes in scholarship constituted such a sample, there would be only one chance in about 100 million, that in the first salary third there would be found as much divergence from the expected 33 per cent as the 45 per cent, which actually occurs, represents. In the same way, in a sample of 247 men made up of those in the last scholarship third, there is only one chance in 9 thousand that the divergence represented by the 22 per cent in the first salary third would occur.

Comparing this group of bars for the men distributed according to scholarship with the next set where they are distributed by campus achievement, the former conclusion that scholarship is the more significant index seems to be rather well borne out, particularly since only 19 per cent of the group won substantial extra curricular achievement, but about 14 per cent were in the first tenth in scholarship and about 40 per cent were in the first third.

The earning of college expenses seems to be of very little significance. At first this seems distinctly surprising but on further reflection there appears to be cause for it. In the first place it is recognized that men earn their way through college not because they are able to but because they have to. Furthermore, although the men with higher earnings were not notably below their fellows in scholarship or in their participation in campus activities, it must be true that such men have sacrificed something in the opportunity for reading, for informal social contacts with their fellows and perhaps most important, the opportunity for reflection and for gaining a broad perspective on the work they are carrying on in college.

On the other hand, the men who have earned their way

have shown a degree of determination and capacity for hard work that it has not been necessary for their fellows to demonstrate. There is no question that these men in general are better off than if they had not gone to college.

Early age at graduation seems to be a small but significantly favorable factor. In fact, in a random sample of 414 men such as those graduating at 20 and 21 make up, there is only one chance out of 21 that as much divergence from the expected 33 per cent in the first salary third as the 38 per cent actually occurring represents and only one chance in 38 that among 264 men, namely those graduating at 24 and over, as much divergence would occur as the 27 per cent in the first salary third represents. The chance, therefore, that both divergences would occur together is about one in eight hundred.

It must be remembered that in this analysis the younger men are also somewhat the better men in scholarship but in combining the two factors more divergence from a normal distribution is obtained than with either factor separately. There seems, therefore, to be some value in early graduation regardless of scholarship but it is distinctly small.

The final set of bars in this chart brings out the value of entering into the Bell System very shortly after graduation. In fact, the first bar comprising about 60 per cent of the whole group is made up of those whose Bell System job was probably their first permanent job. On the other hand, the last bar includes men who spent three or more years in other work before entering the Bell System. It shows a distribution that is only about as favorable as that for the men who graduated in the last third of their class in scholarship. There are, of course, individual cases where outside experience is of definite value in our work. On the whole, however, it seems to be true that a man who finds his field of work first and stays by it will do better in the long run. It should be emphasized, moreover, that this factor is distinctly independent of all the others.

The Influence of Combinations of Factors

Chart 6 shows certain combinations of these factors. For example, the first set of bars covers only the men with substantial campus achievement and distributes them in terms of scholarship. From them, it is seen that the men who were

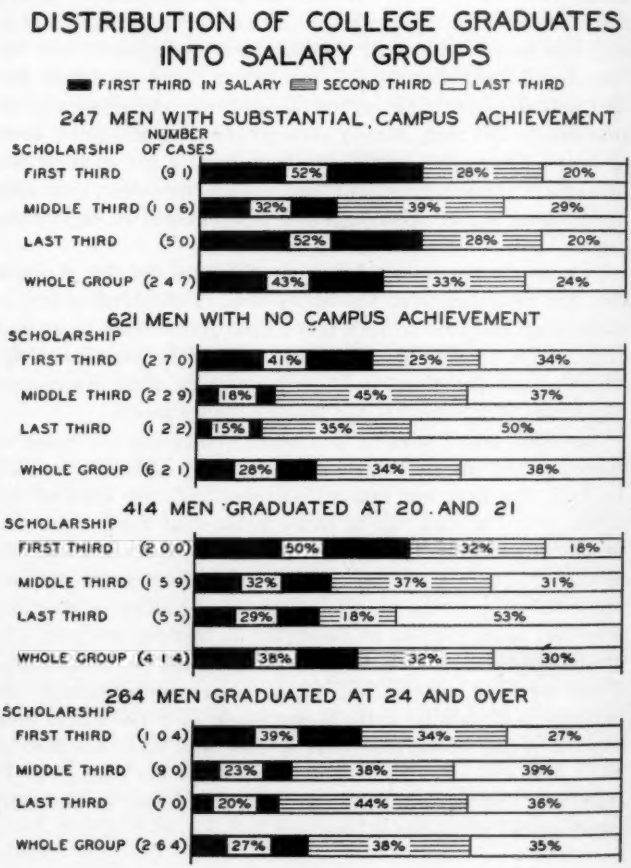
DISTRIBUTION OF COLLEGE GRADUATES INTO SALARY GROUPS
FIRST THIRD IN SALARY
SECOND THIRD
LAST THIRD
247 MEN WITH SUBSTANTIAL CAMPUS ACHIEVEMENT
SCHOLARSHIP
NUMBER OF CASES
FIRST THIRD (9 1) 52% 28% 20%
MIDDLE THIRD (1 0 6) 32% 39% 29%
LAST THIRD (5 0) 52% 28% 20%
WHOLE GROUP (2 4 7) 43% 33% 24%
621 MEN WITH NO CAMPUS ACHIEVEMENT
SCHOLARSHIP
FIRST THIRD (2 7 0) 41% 25% 34%
MIDDLE THIRD (2 2 9) 18% 45% 37%
LAST THIRD (1 2 2) 15% 35% 50%
WHOLE GROUP (6 2 1) 28% 34% 38%
414 MEN GRADUATED AT 20 AND 21
SCHOLARSHIP
FIRST THIRD (2 0 0) 50% 32% 18%
MIDDLE THIRD (1 5 9) 32% 37% 31%
LAST THIRD (5 5) 29% 18% 53%
WHOLE GROUP (4 1 4) 38% 32% 30%
264 MEN GRADUATED AT 24 AND OVER
SCHOLARSHIP
FIRST THIRD (1 0 4) 39% 34% 27%
MIDDLE THIRD (9 0) 23% 38% 39%
LAST THIRD (7 0) 20% 44% 36%
WHOLE GROUP (2 6 4) 27% 38% 35%

CHART 6.

both outstanding in campus activities and who were good students won somewhat greater success than those who were merely good students or merely outstanding in campus activities. The combination of the two factors, however, does not give strikingly more significant results.

There is here, too, one definite variation from the favorable influence of scholarship. Of the men who won substantial campus achievement those who graduated in the last third of their classes are doing about as well as those who graduated in the first third. This is probably due in part to individual variations and might not be found with larger samples. It is true also that there were in this last third group a number of men with rather unusual campus achievement and that although that group includes a number of men whose salaries were sufficiently high to place then in the first third of the group studied, it does not contain as high a proportion of men of the very highest salaries and of those who are making the most permanent contributions to the policy and science of the System as does the group of first third men. Among men with no campus achievement, scholarship seems to be an exceedingly important factor.

The last two sets of bars combine scholarship and age at graduation. Since this combination gives more striking results than either factor alone, it brings out the fact that each of them, regardless of their inter-relations, seems to be important. These bars also show other rather interesting results. Of the men who graduated at the age of 20 and 21 but who were in the last third of their class, nearly a normal proportion are now in the first third in salary but the number of those in the middle third in salary is small and that of those in the last third is distinctly large. Evidently the men who have the ability to graduate at 20 and 21 but who do a rather poor job scholastically, if they do not succeed reasonably well, are very likely not to succeed at all. This group may contain those with good ability but who are distinctly unstable. On the other hand, of the men who graduated at 24 and over in the last third of their class in scholarship, a

very considerable proportion is now in the middle third of their group in salary.

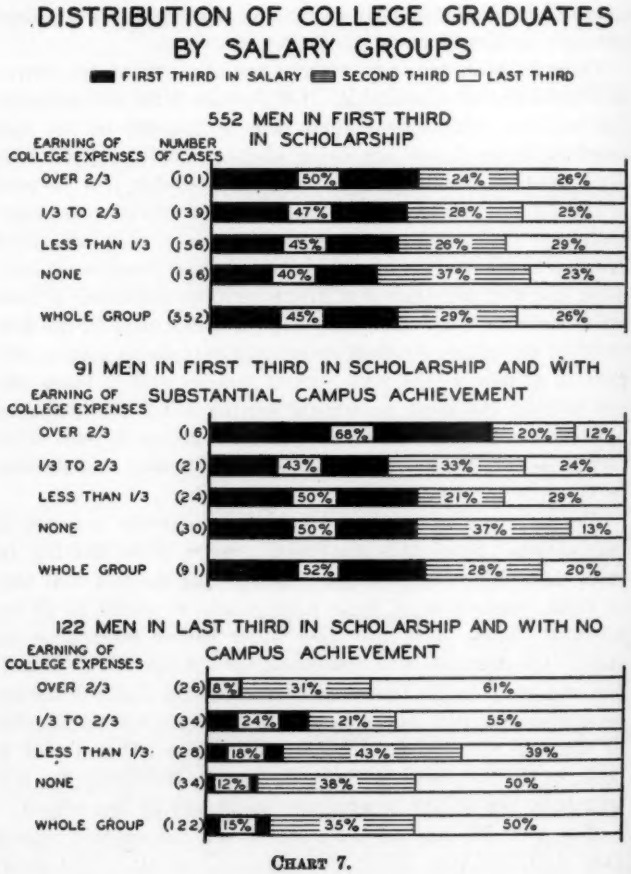
DISTRIBUTION OF COLLEGE GRADUATES BY SALARY GROUPS
FIRST THIRD IN SALARY
SECOND THIRD
LAST THIRD
552 MEN IN FIRST THIRD IN SCHOLARSHIP
EARNING OF COLLEGE EXPENSES
NUMBER OF CASES
OVER 2/3 (101) 50% 24% 26%
1/3 TO 2/3 (139) 47% 28% 25%
LESS THAN 1/3 (156) 45% 26% 29%
NONE (156) 40% 37% 23%
WHOLE GROUP (552) 45% 29% 26%
91 MEN IN FIRST THIRD IN SCHOLARSHIP AND WITH SUBSTANTIAL CAMPUS ACHIEVEMENT
EARNING OF COLLEGE EXPENSES
OVER 2/3 (16) 68% 20% 12%
1/3 TO 2/3 (21) 43% 33% 24%
LESS THAN 1/3 (24) 50% 21% 29%
NONE (30) 50% 37% 13%
WHOLE GROUP (91) 52% 28% 20%
122 MEN IN LAST THIRD IN SCHOLARSHIP AND WITH NO CAMPUS ACHIEVEMENT
EARNING OF COLLEGE EXPENSES
OVER 2/3 (26) 8% 31% 61%
1/3 TO 2/3 (34) 24% 21% 55%
LESS THAN 1/3 (28) 18% 43% 39%
NONE (34) 12% 38% 50%
WHOLE GROUP (122) 15% 35% 50%

CHART 7.

The first set of bars in Chart 7 distributes men in the first third of their class in scholarship by earning of college expenses. It indicates that where scholarship is kept constant

the degree of earning does seem to have some significance but not a striking one.

The next set of bars takes the 91 men who were both good students and won substantial campus achievement and considers them in terms of college earnings. The first bar of this set covers the most highly selected group in the whole study, those who were good students, were active on the campus and who earned over two-thirds of their way through college. It is not surprising that 11 of these men are now in the first third of their group in salary. It is somewhat surprising that 3 of them are in the middle third and that 2 of them are in the last third. Of course, the sample is too small for final appraisal of these results.

In these bars the degree of earning among highly selected men seems to be relatively unimportant and in the final set of bars it seems to have no importance at all. In fact the smallest proportion of successful men of any group is found in that group of men who earned over two-thirds of their way through college but who were in the last third in scholarship and who won no extra curricular achievement. Here again, the sample is rather small but it does appear that these men may well have sacrificed too much to go to college and that a high degree of earning is not compensation for failure to realize the other advantages of college life.

Conclusion

In conclusion there are two general observations which should be made. In the first place, it is recognized that there is no evidence of the effect of native ability in attaining success in the Bell System or in attaining college success. It has undoubtedly played a real part. It seems inevitable, however, that the effective work habits and the determination to do every undertaking well which helped some of these men to win success in college, have been equally important in their later achievement.

It is impossible, however, to answer this question effectively for this group. It is agreed that there is no test of native ability for mature men of varying ages. It may be possible,

however, to throw some light on it in the future. We now plan to obtain information on the results of tests which were given to men employed by us when they entered college. In doing this we recognize that most of these tests are called scholastic aptitude tests. They are given primarily to throw light on the probability of scholastic success. Formerly such tests were called intelligence tests but that practice has usually been abandoned. It may very well be that their results will not in any sense correlate with business success. The experiment, however, is worth trying.

Finally, these charts seem to indicate that good scholarship, campus achievement, early graduation, in that order are significant indices of success in the Bell System. Earnings in college are not significant. On the other hand, it has been found that not all the members of the groups which were highly selected by combinations of these several factors do succeed. It is very evident that other elements are highly important. What all of these elements are, we have no way of knowing. They certainly include a man's ability to adjust himself to the environment of his home and of his business as distinct from his ability to adjust himself to the environment of college. Another important element seems to be interest in and individual ability to do the work which a man has selected for his life work. Still another is the degree to which the organization with which he is connected can offer rewards which are in line with his most fundamental motives.

It is certainly true that the student who has done well in college, if he is to realize on the capacity and promise thus shown, cannot afford to neglect a careful analysis of himself and a thorough consideration of the businesses where his talents are most likely to be useful. He who has done badly in college has no occasion to believe that his pace has been permanently set. If he has discovered his own motives, his own interests and ability, if he has gained perspective on the things which may have hindered him in college, he may well choose a field of work in which he will surpass the men whose college achievement is more spectacular. In this regard, the

industries who are employing college men carry a very grave responsibility. In employing these men they must adopt the broad point of view and must consider not only the degree of general promise which a man has but whether or not he is likely to succeed in that industry, whether or not they have his kind of work, and can offer him the type of reward which will maintain his enthusiasm.

Last of all it is very clear that the opportunity which college personnel and placement officers have is a very great one. It is they who can help the student to solve problems which he may encounter in college; who can develop with him a method of meeting such problems when they occur in later life. It is they who should help him to discover what the requirements and rewards af various businesses are and interpret these requirements and rewards to each student in the light of his own capacity and fundamental motives.

DEAN M. E. COOLEY'S REMARKS UPON RECEIVING THE WASHINGTON AWARD FROM THE WESTERN SOCIETY OF ENGINEERS *

The Washington Award in recognition of devoted, unselfish and pre-eminent service in advancing human progress conferred in 1930 upon Mortimer Elwyn Cooley for vision and constructive leadership in the education of the engineer.

Awarded by the Western Society of Engineers on the recommendation of Commission of Award, representing American Society of Civil Engineers, American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Western Society of Engineers.

I deeply appreciate the honor of having been selected to receive The Washington Award for 1930. It had not occurred to me that I was one to participate as a principal on so great an occasion as this. To me, it seemed the honor should descend on those whose work was outstanding in more specific ways than mine. And, too, I looked upon myself as one to *do* homage, rather than to *receive* homage. And yet there is a serenity, a deep joy, a great satisfaction that floods my being in realizing—trying to realize what this token indicates; that I have the esteem, the approval, of more than sixty thousand of my colleagues for my part of the work in our common vineyard of ideals and hopes for the engineering profession. I bow my head in salutation and thanks for this graciousness which has been vouchsafed me.

It is education, engineering education, that has absorbed my working life. And so I feel I should set before you on this occasion a *résumé* of the periods marking its development as they appear to me. As in all things having the time element, there is in education a past, a present and a future. I need

* *Journal, Western Society of Engineers*, Vol. XXXV, April, 1930, No. 2.

not dwell on the marvels that have come to pass as the result of the work of the engineer. Suffice it to say, they are the core of what we term our modern civilization; that without them such a civilization would not, could not, be. But what of the future? Shall it be something more,

> "To marvel at and while away
> The time until another day?"

Or shall it embrace wisdom to control our flights into the unknown, and make us conscious of our responsibility for the uncontrolled psychological effects that follow such flights? These we have ignored. Not engineers alone, but almost everyone. The present is a period of achievements. The future must be a period of responsibility for achievement, lest achievement fail.

With this glimpse of the present and future, let us take up the past.

And where shall we begin?

> "Out of chaos came cosmos; then followed the sun,
> "And the earth, and all else since the world was begun—
> "Down to Man."

We are told that the "Gin" in "engineer" is from the same root (meaning to create) as "GEN" in "Genesis." Not to be irreverent, that would take us back to the Creation. Far enough, you will say. Rather would I use the reference to dignify the title we bear, and our responsibility to hold it dear and keep it clear.

Who among us has not wondered about engineering in the silent past? Could it be known, what use might not be made of it? Like the back-sight in surveying, could it not be used to correct our foresight into our own future? Not, of course, as concerns the discoveries of science and their applications characteristic of our age, but of the ever old, ever new human response and reaction to new things and conditions marking progress.

Only now are we beginning to know about ancient engineering through archaeological research. All around the Mediterranean basin, the eastward into Mesopotamia, the Indies,

China, and in our own hemisphere, the discoveries indicate that early engineering had progressed far. Relatively, for aught we know, it had progressed as far as today. In the period of the Renaissance, there was Leonardo da Vinci, than whom no greater could be mentioned today if we keep in mind the difference in time and conditions. More recent is our own George Washington, the surveyor, as we think of him. But engineers in our country are descended from the surveyor. It was President Washington who recommended, during his administration, a school for artillerists and engineers, later established at West Point.

Curiously enough, the greatest steps forward in the arts and sciences have been coincident with great wars. Not so curious after all, when we think of the tremendous demand made on all the resources, mental, physical, spiritual, and material, of warring peoples. As instance, the late World War, in which the scientist and engineer waged so great a part. It was in our Revolutionary War days that James Watt's great invention marked the beginning of the age of steam. And it was during our war between the states that Lenoir's internal combustion engine marked the beginning of the gas-engine age. Between these two dates it might almost be said that the engineer, like Topsy, "just grew." The United States Military Academy, recommended by Washington and established in 1794, really began to function in 1817. It was, of course, military engineering that was taught there. Next came Renssalaer Polytechnic Institute in 1824, in which civil, as distinguished from military, engineering was taught. Civil engineering as such occupied the foreground for many years. Descended from the surveyor, civil engineering in turn sired a numerous progeny. Mining engineering, a near relative, if not a son, was established at Columbia University in 1864. Stevens Institute of Technology came into being in 1870 with mechanical engineering.

The state universities were not far behind. In the University of Michigan, for instance, provision was made for a chair of civil engineering in its reorganization act of 1837. Its first professor of engineering was appointed in 1853, and

its first graduates were in 1860. Courses in mechanical engineering were established in 1868, but no separate distinctive degree was at that time conferred.

From 1875 on, the number of engineering schools increased rapidly, until at the present time there are about one hundred and fifty in this country alone.

Strange as it may seem, the education of the engineer of earlier years was broader than it is today. In the universities, engineering was not a separate department as nowadays, but was a course of study in the liberal arts colleges. Then, too, there were comparatively few textbooks on engineering, and in a four-year course the work required for graduation, of necessity, included many so-called cultural studies. Thus it was not uncommon to find both Latin and Greek among the accomplishments of engineering graduates.

The older men present will readily recall some of the distinguished engineers following the Civil War. It was a period of great expansion. The development of our West was in progress. Our transcontinental railroads were being built, and great bridges were beginning to span our largest rivers. The engineer of those days, being liberally trained, was a man of vision, a wise counselor in great enterprises—those which involved knowledge of people as well as of technical things.

It was during the last quarter of the century that engineering education really came to be the great force it now is. In the first part of the period the engineer graduate had hard work to find employment. Employers wanted *practical* men —those who could do something at once. That was particularly true of mechanical engineers. A salary of $50 a month was big for a man just out of college. But towards the end of the period the attitude of the employer changed completely about. He not only welcomed graduates, but sought them. For a number of years, agents of the industries have been visiting engineering schools in mid-winter and early spring to look over the senior classes and offer employment. It is not unusual for practically every man to have employment awaiting him on graduation.

The president of one of our largest steel corporations wrote the late President Angell requesting that he choose for him thirty or forty of his prize graduates every year. The college or department was not important. What he wanted was trained and disciplined minds. He would fit them for their place in his organization. That was soon after 1900, the beginning of the present period of engineering education. What better could illustrate the great transformation of attitude of employer towards the college-trained man?

During the period preceding 1900 engineering curricula were in a state of flux. They were constantly changing, partly because of new branches of engineering, and partly because of rapid developments in a particular branch. The less than half-dozen textbooks of the seventies had multiplied many fold. Knowledge of the sciences had greatly increased. Things that are now common necessities were then being created. Broadening studies had to be dropped to make room for the new technical studies. So pressing was the need for room for new studies, it was necessary to increase the number of hours for graduation by the equivalent of a semester's work and still do it all in four years. As one result, only about 40 per cent of those entering college are able to graduate. As another result the men, while splendidly trained in a particular line, are comparatively ignorant in other lines. Let me illustrate by an actual occurrence:

Some twenty years ago a manufacturer complained to me that we were not being fair to our students, still less fair to their employers; that while the men sent out knew a lot about some particular thing, they did not know anything else. He had, on his staff, graduates of half a dozen engineering colleges, and said he could get all he wanted, and the best of them, for from $1,500 to $2,500 a year. What he wanted, he said, was men who could earn $25,000 a year, men who had some knowledge of things in general, and not merely of how to design and build things. That kind the colleges were not training. His was a lone voice in that day. Now there are hundreds, if not thousands, who would welcome more broadly trained graduates from our engineering schools.

While the engineering curriculum has never remained fixed for any great length of time, it gradually became more or less stable in the years around 1900. As written, the curriculum was thought to anticipate the requirements of the country as they were then visioned. That it has done so is evidenced by the remarkable series of industrial developments following one after the other so closely that the wonder of yesterday has become the necessity of today. And in this period have come great social and economic problems as the result of our industrial development, and also as the result of our rapidly increasing population.

With only a little thought, one cannot help wondering how long and how far we can go in supplanting men by machinery. A machine that does the work of thirty men leaves twenty-nine to seek other employment. They are absorbed for a time—during periods of so-called prosperity. But prosperity requires a disposal of thing made and raised. There is a limit to our home consuming capacity, even were the consumer sufficiently prosperous to buy all he wants. So prosperity becomes the great problem of the future, and how few of the men of today are prepared to solve it? Our training has been to produce in ever-increasing quantities, and the finest talent in the world has been employed to sell what has been produced. And yet our producing capacity far exceeds our consuming capacity. Where does the circle end? What can we do about it?

Summed up, modern education, as I see it, has taught us how to earn money more easily, but not how to spend it more wisely. It has broadened the scope of human endeavor, opened the way to unparalleled wealth, and enabled us to live midst marvelous material surroundings. But in so doing it has narrowed human relations, dulled our appreciation of natural pleasures and lessened our sense of spiritual values. It has loosed forces which until balanced must inevitably lead as their resultant points, be it for good or for evil.

That brings us to engineering education in the future. Not alone engineering education, but all education. It is a condition that affects society that must be solved, not only in this

country, but in all civilized countries. Science and its applications have made us all neighbors, so near that the most distant points are within reach of the human voice, as witness a message from Admiral Byrd near the South Pole to New York by way of Greenland. Our progress towards a finer civilization has led to a great unrest. We are told that, at present rates of increase, our population will reach our food-producing capacity in a frightfully short time, as we think of time. What of conditions then? It is none too soon to begin to prepare for them. Engineering education in the future must do its part in conjunction and in harmony with education in other fields.

A cessation of discovery and invention is inconceivable at a time when the world is agog for what may come next. Our prosperity is based not so much on the necessities of life as on the luxuries—luxuries which by their indulgence come to be regarded as necessities. Formerly we created our amusements. Today we buy them. Food once raised is now bought. The old bushel of wheat no longer pays for a day's labor in the industrial sections of our country. There is great inequality in the scale of living. For instance, the laborer in the North receives $3 to $4 a day of eight hours; in the South he receives $1 a day from sunrise to sunset. A farmer in the South works a full week to buy himself and wife each a pair of shoes at $2.75 a pair. A share cropper in the South, with his family of a half-dozen children, lives on less than $300 per year. These and many other inequalities that could be mentioned indicate the need of new studies in our schools, those that would prepare us to meet the conditions that have grown out of the present curriculum, studies that would restore our balance, if it be possible.

To that end, and for engineers, I would, without greatly disturbing present requirements, add to the curriculum studies that would first of all enable comprehension of existing conditions and their cause. I would then add studies of the epochs in which engineering achievement has greatly changed the conditions of life, going back to earliest civilizations as they are uncovered. The rise and fall of nations

should have a place—the sources of wealth; the effect of wealth; the effect of wealth on prosperity; the relation of natural resources to wealth and prosperity; the probable duration of our natural resources and conditions after exhaustion of certain of them. These studies alone, coupled with the logical mind of the engineer, should go far towards connecting cause and effect, and, reasoning by analogy, would enable him to vision the future of its broader aspects. Of the greatest importance are studies that train for citizenship, particularly in this country of ours in which individuals have a share in the government, and are responsible for its welfare.

The studies added would lengthen the course so as to require more than four years for its completion. But five and six years are now required in law and medicine. Why not in engineering? Let us, for example, take five years and spread over that period the same amount of technical study as is required at present. We would gain the equivalent of one year for non-technical study, and this, together with present non-technical studies, should likewise be spread over the five years. The course as a whole would be composed of strips, or ribbons, five years long, each devoted to a subject, or group of kindred subjects. At the end of four years, while the student would not have gone quite as far as now in a technical subject, he would have gone far enough to do substantially what is now required of him on graduation. But he would go forth with a richer education, one that would enable him to get more out of life for himself, and give more to others. The great body of engineer graduates required by industry would continue to be available as at present. It is to be presumed that during the adjustment period, most students would have neither the time nor inclination for more than four years. As the adjustment proceeds, the number taking the longer course would increase and eventually become the greater.

Those who go on would, at the end of five years, find themselves equipped with advanced technical training and a deeper insight into subjects fitting them better for the problems to which I have referred. The bachelor's degree conferred at the end of four years would be followed by the master's degree

at the end of five years. Certain of the five-year men would, no doubt, continue on and take their doctor's degree. Thus in this new curriculum new types of engineers, now only rarely available, would be provided, without disturbing greatly the output of the present type.

This new curriculum would also make possible a type of engineer that is bound to appeal to those who believe our future welfare depends on continuing prosperity as in recent years. Such a prosperity demands the disposal of manufactured products in excess of home consumption. That means foreign markets—foreign relations. And foreign relations, to be successful, mean knowledge of foreign peoples, their languages and customs. More than that, it means knowledge of their industries, and the conditions to be met in trading with them. Knowledge of their industries would require study, both engineering and economic. The engineer who has spent additional time in college should be especially well prepared for such service.

Engineer graduates are now sent abroad as agents or salesmen for the companies employing them. I would have engineers go abroad as representatives of the government, duly commissioned, with official standing on the staff of our consulates, and in line of promotion to the office of Consul. What better to enhance prosperity than a body of trained experts to look after our commercial interests abroad?

There are now military and naval attachés at our embassies. Why not also engineer attachés? And what an appeal there would be in the idea to those who would do away with war and substitute peaceful pursuits, of which commerce is one.

At home there are equally important public positions to be filled by engineers who have taken the longer and broader college course. Confronting our government are great engineering problems. The Congress must enact laws to deal with them. Likewise the states have their great engineering problems requiring the enactment of laws by the state legislatures. Foreign governments have engineers and scientists in their legislative bodies. Japan has thirty or more, France, Italy, Great Britain, and no doubt other countries have them.

How many engineers and scientists are to be found in our own legislative bodies? I know of two, possibly three in Congress. Probably there are more, but the news from Washington does not indicate it.

I am hoping that my dream of engineers in foreign public service, and in our own public service, is about to come true. Nothing could be more stimulating to our profession of engineering than a goodly number of its members in high public places. It is a duty the profession owes to our country. We started under an engineer whose name has special significance on this occasion, and after 150 years we again have an engineer at the helm of state whose name, too, has special significance, in that it heads the list of those who have been so signally honored as recipients of The Washington Award. Let us not forget the duty that rests upon us as engineers, individually and collectively, to do the utmost in our power to promote the success of our engineer President in administering the affairs of a country that, largely as the result of its engineering achievements, stands foremost among all the nations.

MODEL FACTORY IN THE ENGINEERING COLLEGE

By A. P. GWIAZDOWSKI, *Assistant Professor,* College of Engineering, U. of M.

The object of this article is to show what an average student can accomplish in 240 hours, if his courses are wisely designed, and his efforts during the execution of the tasks are properly guided.

Shop Courses Offered by the U. of M.

The University of Michigan offers three machine shop courses, known as *Shop 4, Shop 4-A, and Shop 7.* Shop 4 consists of six hours per week of laboratory, and two hours of class-room work, or a total of about 240 hours. In the laboratory the students are taught to operate engine lathes, milling machines, planers, shapers, cylindrical, surface, disc and tool grinders, drill presses, turret lathes, screw machines, gear cutting machines, broaching machines, polishing and buffing stands. The Class-room work consists of preparation for laboratory tasks, and the discussions of such subjects as proper sharpening of tools and milling cutters, chip formation, relation of speeds and feeds to the tool life and power consumption, problems of gearing, die-casting and power presses; the importance of coolants and lubricants, time and motion study, accounting, factory organization and the keeping of stock records. In addition to the above, students spend three afternoons doing research work in metal cutting under the supervision of Professor O. W. Boston, head of the department.

Shop 4-A is available to those who have previously taken Shop 4. In this course they get more advanced shop work and machine-tool designing. They also work on research projects. This course is elective, 120 or 240 hours.

Shop 7 is tool designing, and is also elective, 120 hours.

Students taking Shop 4-A do work similar to that done by the engineering department in a factory. Their business is to design machine tools, such as drill presses, lathes, milling machines or shapers. These are made according to the following rough specifications:

1. The machine-tools designed will be actually built, and, therefore, the design must be properly executed. Ease and convenience of operation, compactness, simplicity of operating mechanisms, provisions for the removal of chips, adequate lubrication, combination of operations, universal adaptability of machine or device, are the factors to be kept in mind by a machine designer. *Seriousness of purpose* is impressed as a first prerequisite of the work.
2. Patterns and castings are made in the University pattern shop and foundry. The designers have, therefore, a chance to consult the instructors of these departments frequently, in order to make sure that the designs can be executed without special equipment or tools. *Methods of molding, forging and standardization* are discussed during these consultations.
3. The execution of the details should be as close to the drafting room practice of the Detroit factories as possible. Shop terms and shop practice, therefore, of automobile manufacturers are closely followed.
4. The designer's duty is to check the patterns. *Accuracy and proper execution of details* are impressed at this stage of the work.
5. A variety of metals should be used in order to give the students a chance to experiment with cast iron, steel, aluminum, bronze and other metals.
6. Limits are used when needed.
7. The students are taught to adapt themselves to different shop conditions. They are told what would be done in a shop, manufacturing 100,000 parts, but they must make their designs suitable to our equipment and to our production.

To illustrate how this method of instruction works, the class taking Shop 4-A in 1928–29, designed a Bench Drill Press (Fig. 1). The details were designed in such a way that every standard type of machine tool in the engineering shop could be used for their machining.

The main parts are made of cast iron, the bushings are of bronze, and the pulleys are of aluminum. Hot rolled, cold drawn and alloy steels are used for the shafts and the spindle.

As soon as details were checked by the instructor, they were passed to the students, taking Shop 7. Their business was to "tool up" each part of the machine, prepare operation

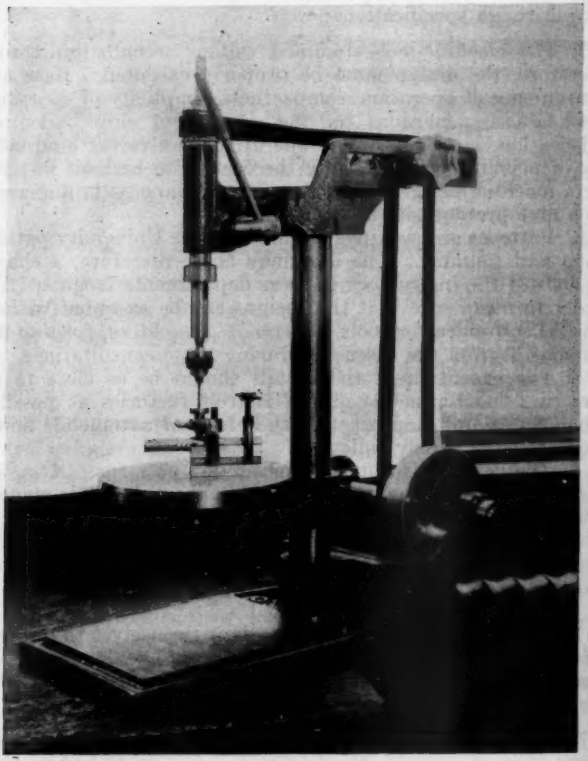

FIG. 1. Drill press built by Robert Sueæ, engineering student from China.

sheets and instructions, also to estimate the time of machining. This class corresponds to the *Factory Production Department.*

"Tooling Up" Bench Drill Press Parts

This class was organized for the first time, and did not have college traditions or accumulated information of the past years in the form of drawings, standards and notes. The

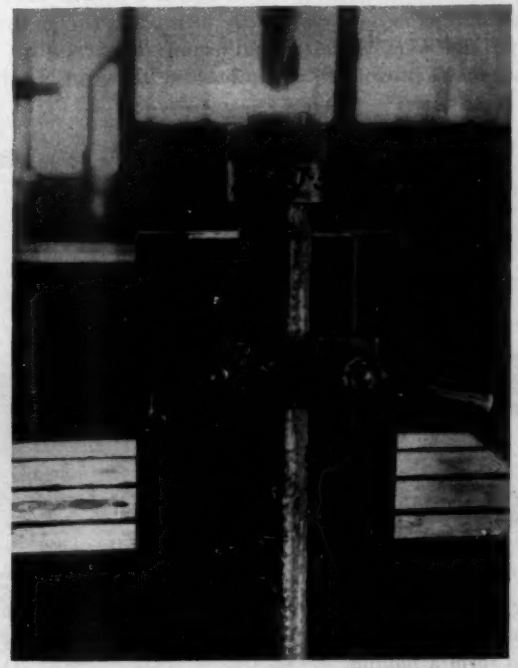

Fig. 2. Holding fixture and drill jig for columns 264–3.

analysis of some of the designs will prove that the method chosen by us produced very good results.

Column, part No. 3, is a cast iron pipe. It is necessary to drill both ends for center inserts. Figure 2 shows the holding fixture No. 264–F–3, and Drill Jig No. 264–J–3. Reasonable accuracy and speed are the results of this simple outfit used on the Radial Drill Press.

Drilling four holes, 3/16″ in diameter, tangent to each other, for the spindle drift slot, was quite a problem. An ordinary standard tool-room V-block has been transformed into a Drill Jig No. 264–J–7 (Fig. 3). The standard clamp holds the work which is to be drilled for a drift slot. The holding screw is provided with a copper tip to prevent marring the work. The second clamp *B* carries an offset bushing plate, in which is a slip bushing that can be adjusted

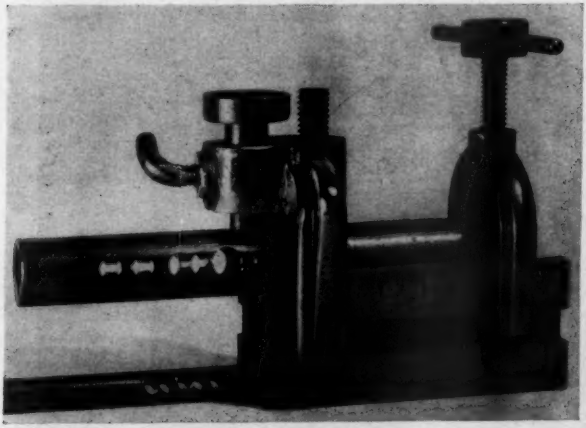

Fig. 3. Drill jig for round work.

up or down, according to the diameter of the work. The bushing is held in place by a threaded rod, bent at the outer end to form a handle.

After the first hole has been drilled, the screw *C* is loosened and the clamp is moved to the right an amount equal to the diameter of the drill. Then the next hole is drilled. This procedure is repeated until the last hole has been drilled. The new position of the bushing for each hole can be accurately located with the help of engraved graduations.

Boring two holes in the spindle arm (Fig. 4) was a very tedious milling machine job. Boring Jig No. 254–J–4 solved the problem. A single spindle Barnes Production

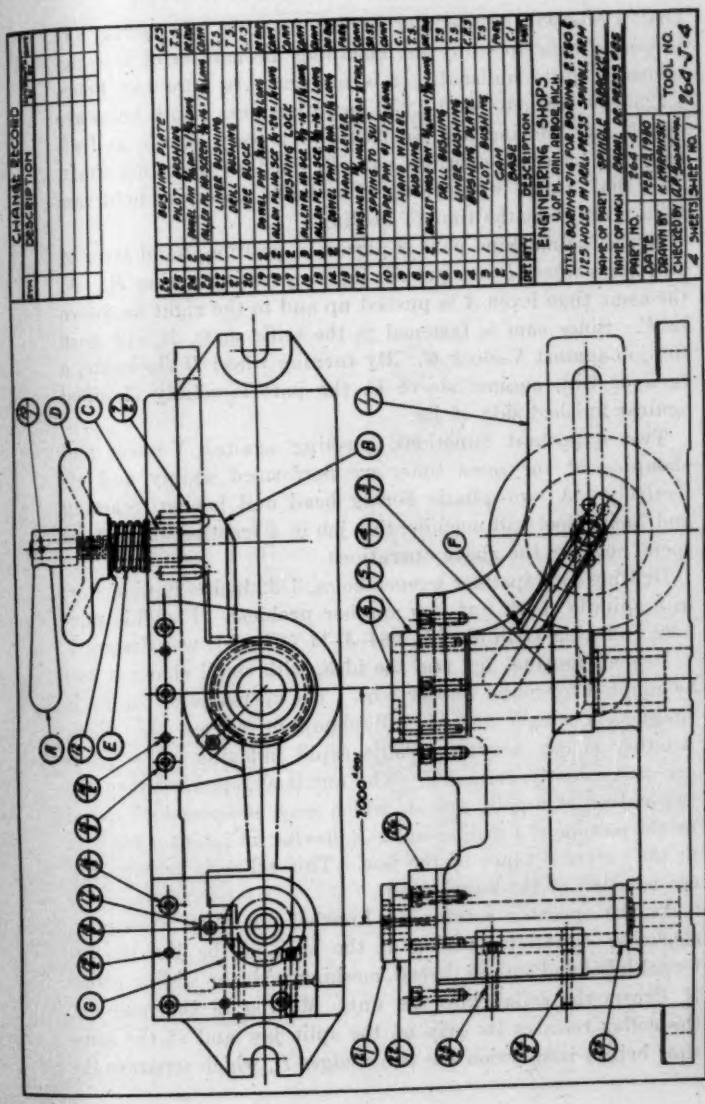

Fig. 4. Boring jig 264-J-4.

Drill Press will be used for boring, reaming and facing. It is worth while to study the clamping mechanism of this jig, which is quite unusual. It is necessary to bore two holes, 1.125 inch diameter and 2.250 inch diameter. Both holes are cored out. Boring Jig No. 264–J–4 is very simple and effective. Lever *A* operates cam *B*, fixed to the same shaft. This shaft turns in sleeve *C*. Two bullet nose pins hold cam *B* in position at the time of loading.

After the machine part is placed in position, hand lever *A* and hand wheel *D* are pushed in, compressing spring *E*. At the same time lever *A* is pushed up and to the right as shown in *F*. Since cam is fastened to the same shaft, it will push the job against V-block *G*. By turning wheel *D* clockwise, a turn or two, against sleeve *C*, the part is solidly clamped against finished side of jig.

Two important functions, pushing against V-block and clamping at the same time, are performed simply and effectively. A two-spindle boring head and boring, reaming and facing tool will machine this job in a fraction of the time spent now for the above operations.

Drilling four spanner wrench holes, 3/32 inches in diameter, in a spindle check nut was another problem. For this purpose Indexing Drill Jig No. 264–J–11 (Fig. 5), was designed.

It is an unusual jig, and the idea, with small changes, can be adopted for many similar jobs. The operation of the jig is simple. A single motion will clamp or release the piece. Another simple motion permits rapid indexing. The parts are conveniently arranged. The nut is clamped between the two halves of a split jaw *A*, which may be opened or closed by the motion of a sliding collar *B*, having an internal taper to fit the external taper of the jaw. This collar is actuated by the rotation of the knurled nut.

As the operator rotates the knurled nut *C* in a counterclockwise direction, looking at the back of the jig, the internal left hand square thread, meshing with the sliding collar *B*, draws the collar into the nut. Moving in this manner, the collar releases its grip on the split jaw and at the same time brings into action the two wedges *D*, which separate the

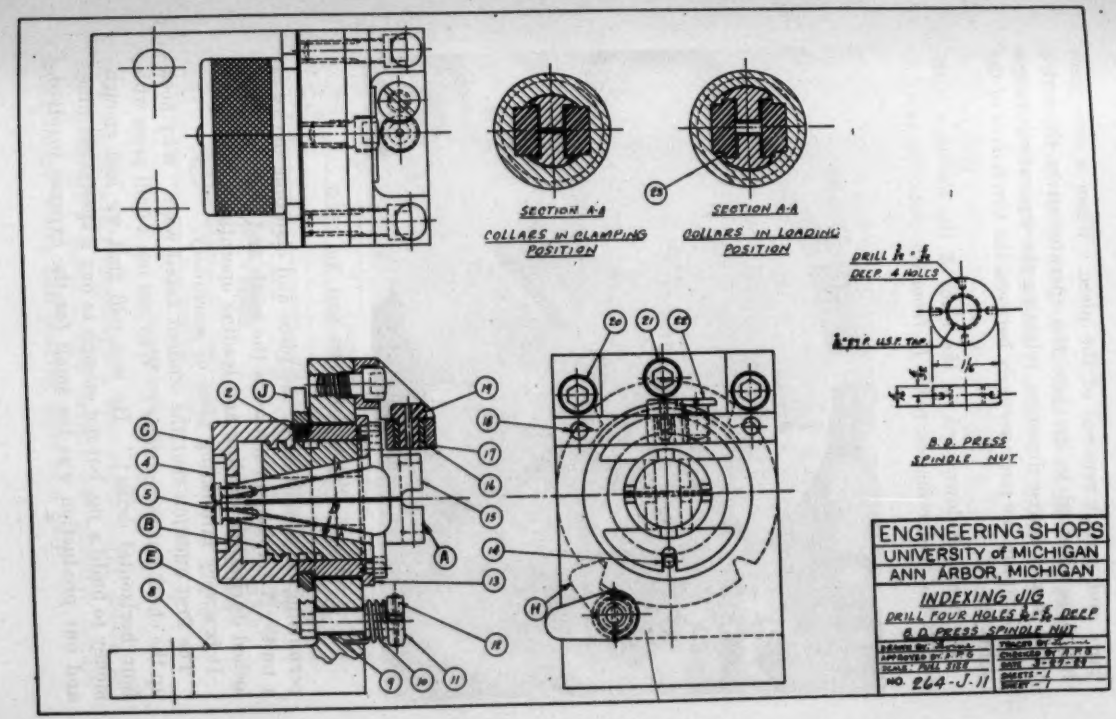

Fig. 5. Indexing drill jig 264–J–11.

jaws and permit removal of the piece. When a new piece has been inserted in the jaw, the operator gives the nut a twist in a clockwise direction, releasing the separating wedges and clamping the piece securely between the two halves of the split jaw.

By pressing downward on the lever *E* the operator withdraws the wedge-shaped tooth *H* from the indexing plate *J*,

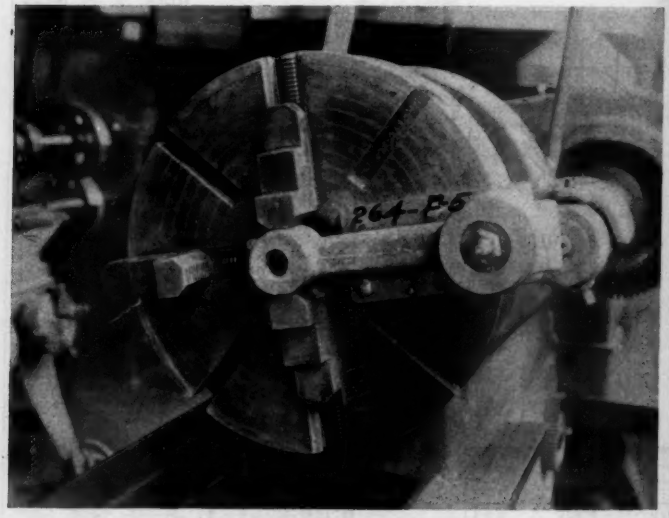

FIG. 6. Boring fixture for part No. 264–5.

permitting easy rotation of the piece and clamping device as a unit. A torsion spring keeps the tooth and indexing plate locked during the drilling and loading operations.

It is a very interesting piece of machinery.

The first question that the student asked was: "Why hook up the check nut to anything? Why not use a drill press with four horizontal drills?" He was told that we had enough money to build a jig, but not enough to buy a special machine, and our production was too small for the expense involved.

He developed seven designs, the last of which was finally accepted by the instructor (Jig No. 264–J–11, Fig. 5).

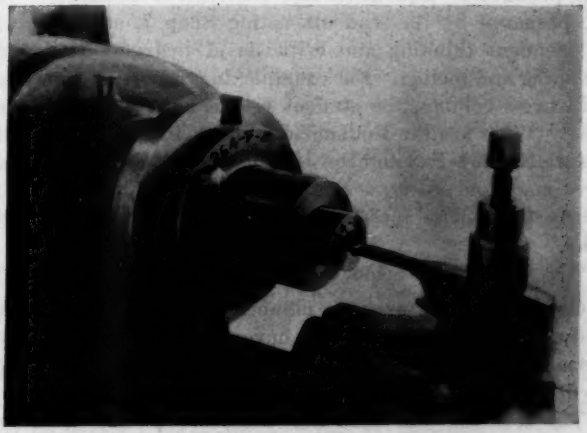

FIG. 7. Fixture 264–F–8 for boring bearing seat in a quill.

Fixture No. 264–F–5 and Multiple Drill Head No. 264–H–5 have been designed for boring two holes in the Table Arm,

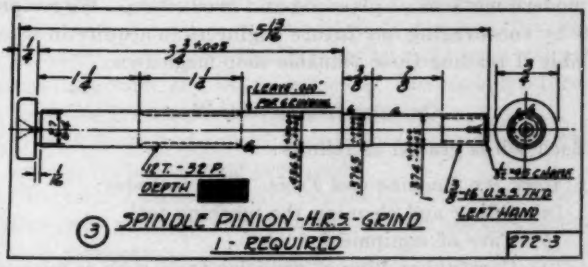

FIG 8. Operation instruction sheet.

Part No. 5, which supersedes a very crude outfit, shown in Fig. 6. Fig. 7 shows a very simple but effective fixture 264–F–8 for boring ball bearing seats in a quill.

As soon as the drawings and castings were ready, the class taking Shop 4, stepped in. Their business was to machine parts and assemble them into a complete product. They are real producers. Operation and Instruction sheets (see Fig 8), prepared by the students taking Shop 7, encourage the independent thinking and criticism of instruction methods, clamping and tooling. For example, in a report on machining drill press column, the student is asked the following question: "What are the fundamental errors in the design of the fixture No. 264–F–3 and the Jig No. 264–J–3?" These errors were made purposely so that the student would have opportunity to criticize the device and be on the lookout all the time.

Use of Incentive

Our jigs and fixtures are planned and designed very carefully. A number of them have been published in the "American Machinist," and "Master Drawing of Multiple Drill Head" in "Machinery."

The fact that the students' ideas are published in such nationally known magazines as "American Machinist" and "Machinery" serves as a good incentive.

Incidentally "American Machinist" and Machinery" are assisting us in turning out graduates with a better knowledge of modern methods of planning and production. We reciprocate by encouraging our future engineers to acquire in school a habit of reading these valuable shop magazines.

Grading Laboratory Work

Each job is graded as follows:

1. *Care for Machine and Tools.* This includes:
   (*a*) Oiling and cleaning the machine tool.
   (*b*) Care of equipment.
   (*c*) Careful handling of precision tools, such as micrometers, try-squares and height gages.
   (*d*) Cleaning small tools before returning them to the tool-crib.
2. *Sequence of Operations.*

3. *Effort and use of principles.*

4. *Accuracy.* Work need not be done over for lack of accuracy.

5. *Finish* or workmanship as indicated by the finished part.

6. *Time used to complete job, or percentage of job completed in allowed time.*

7. *Resourcefulness in advanced work.* Nothing should be taken for granted. Instructions and equipment should be checked. Students should plan their own methods of clamping, sharpening tools, and setting up jobs. After preliminary exercises experiments may be made with speeds, feeds, clearance and rake angles, and methods of clamping.

8. *Reports.*—More advanced jobs involve original methods of machining and peculiar ways of clamping. The student should report his observations in a short way, using sketches and giving conclusions. These reports are valuable to the instructor, but they are priceless to the student: he is learning to make systematic observations, to arrange them properly and transmit them to another man by means of the universal engineering language—a sketch or drawing.

9. *Operation Sheet.*—This illustrates how the student is progressing.

Results

The following results are obtained with this system:

1. The student realizes that he is producing a useful piece of machinery, and knows that it must be right or it will not pass the inspection, and will be rejected. His ambition forces him to do his best to produce a good job.

2. Jigs, fixtures and special tools bring him in contact with the modern system of mass production.

3. He realizes, right from the beginning, the importance of his laboratory work for other courses, such as machine design and shop management.

4. He begins to think and to express his ideas in shop terms.

5. Laboratory work and classroom studies are in harmony.

Operation Sheet

Part No. 272–3

Operation No. 1. Machine Tool, Tools, and Accessories: (*a*) Centering Machine No. 152.

Operation No. 2. Machine Tool, Tools, and Accessories: (*a*) Engine Lathe to be assigned by instructor, (*b*) Facing Tool, (*c*) Right Hand Turning Tool, (*d*) Cut-off Tool, (*e*) Cutmeter, (*f*) Scale, (*g*) Outside Calipers, 4 in., (*h*) Vernier Calipers, ((*i*) 1-inch Micrometer, (*j*) Clamp Dog.

Machining: (*a*) Face both ends to size. (*b*) Turn diameters to rough size. Check sizes with outside calipers. (*c*) Turn undercut with cut-off tool. (*d*) Turn to finish size. Check sizes with micrometer.

Speed Rough———— Feed, Rough————
Speed Finish———— Feed, Finish————
Time ————

Operation No. 3.

Grind to size on Landis Universal Grinder No. 117.

Operation No. 4.

Machine Tool, Tools and Accessories: (*a*) Lathe No.——— (*b*) Thread Tool, (*c*) Center Gage, (*d*) Thread Gage.

Machining: (*a*) Set tool at right angles to axis of work by using center gage. (*b*) Adjust feed to cut 16 threads per inch. (*c*) Make light trial cut and measure threads per inch with scale. (*d*) Cut threads to depth.

Speed ————Feed ————Time ————

Operation No. 5.

Machine Tool, Tools and Accessories: (*a*) Milling Machine No.——— (*b*) Dividing Head, (*c*) Formed Cutter to cut 12T–32P and arbor, (*d*) Screw Jack.

Machining: (*a*) Set up job in dividing head. (*b*) Adjust speeds and feeds. (*c*) Set longitudinal travel of machine table for proper length. (*d*) Feed to depth by hand—Use Power Longitudinal Feed. (*e*) Mill 12 teeth.

Speed ————Feed ————Time ————

Note: For Spur Gear Calculations See Print of Part No. 272–4.

OPINIONS AND OBSERVATIONS ON TEACHERS *

DEAN B. M. BRIGMAN

Speed Scientific School, University of Louisville

Milton, in one of his stately verses says:

> "Accuse not nature; she hath done her part;
> Do thou but thine."

How well I recall the emphasis that my old English professor laid upon these words, and like the teachings of my mother, they remain with me, particularly when "all others are out of step" except me.

Looking back over a period of nearly a quarter of a century in educational work, I recall very vividly the advice given me by the revered former President of the University of Kentucky, James K. Patterson, to whom I always went when I needed inspiration and advice. On this occasion, I consulted him when I was considering my entry into school work. He said, "There are no rules in teaching; you must have a belief in the profession; for teaching *is* a profession." Later on he quoted from an author whose name I do not recall; but in substance it was as follows: the problem of teaching a savage some technical or scientific subject would not be strictly a problem of how to give him sensations regarding it, nor would it be a problem of how to give him the mental capacity to understand it; the big problem would be how to arouse and stimulate his *interest* in such a way that he would set his mind to work upon it.

With this sort of advice as a guide, is it not natural for me to advocate that "interest breeds interest"? To my mind there is nothing so contagious as interest. Professor Charles F. Scott, as reported in the January issue of the JOURNAL OF ENGINEERING EDUCATION, says, "Engineering education must

* Presented at a meeting of the Kentucky Section of the Society.

seek its enrichment from within. It is the teacher who makes a course broad or narrow. Any teacher may make his subject the doorway which admits his students to own life and interests. In our own experience we can recall the teacher . . . who gave us a new vision of the large significance of science or history and their relations to life."

It is my belief that a teacher who is himself teeming with interest in his subject will inspire his students to learn with a similar amount of interest. It is indeed a rare case, if there be such, where the interest manifested by such a teacher would not be absorbed by the class. I also believe that interest will ripen and decay unless the teacher takes advantage of such interest when it is in full bloom. Too frequent is the charge made that the student failures are due to lack of capacity, lack of mental ability, and poor preparation, when in reality the teacher himself, lacking interest in his work, has failed to stimulate the growing mind. He does not understand that interest accompanies natural mental growth, or that knowledge is the basis of interest. One is interested in that concerning which he knows something, and wants to know more. All students know something. A teacher, therefore, should present his subject so that it makes connection with what is already in the mind of the student. Likewise, all students are *interested* in some things. The teacher should discover these things and present his work as an extension of those very things. The teacher, then, will be interesting who can make new things seem old, and old things seem new.

I believe also that it is a good idea to make the student the center of interpretation by teaching *out* from him in all directions. To make the subject reflect one's self is the essence of securing interest.

I once heard Chancellor Bowman of the University of Pittsburgh say that he hoped for the day when teachers would be required to place in writing what each did in his classes and why, and then have the reports reviewed by the others of the staff. His idea was to place the teacher on the same footing as a doctor, an engineer, or a lawyer by requiring that each diagnose, report, or write a brief on his students.

If some such plan would be worked out, I firmly believe that there would be less criticism of mental ability or lack of preparation, and perhaps more recognition of Milton's philosophy as quoted above. One thing, though, would be certain under such a plan—teachers and executives would be more careful in giving a statement, if this opinion would be in writing because, strange as it may seem, some teachers and some executives are *sometimes wrong.*

Chancellor Bowman made the above statement five or six years ago; now let me quote from Bulletin No. 34, Bureau of Education, 1927, on Higher Education Biennial Survey by Arthur J. Klein:

"The most embarrassing question that can be asked of college administrators and of faculty members with reference to the teaching of an institution is: 'How do you know what kind of teaching is going on in this college?' Although in 19 of the 74 institutions studied some form of inspection is reported, it was found that this inspection is in many cases perfunctory or neglected and has not assumed the importance that supervision has in the public schools. There is considerable misunderstanding about this matter. Faculty members resent formal supervision, but would probably be inclined to change their attitude if they fully realized the importance given by administrative officers to student opinion in estimating faculty efficiency. Inquiry at over 50 institutions shows that, whether they know it or not, the faculty is continually subjected to student supervision and report of an informal character which has become of primary importance in the administration's estimate of classroom work. It would seem that expert supervision by mature and trained persons belonging to his own craft would be more acceptable to the college instructor.

"Although faculty members are inclined to resent any direct attempt by the administration to supervise methods of instruction used in the classroom, they are more willing to admit the legitimate interest of the administration in the content of courses. Since the poor quality of college teaching has in part been due to poor organization of the materials of instruction, the practice, now introduced by several institutions, of requiring detailed syllabi of each course tends to improve classroom work. It requires careful analysis of the material and ground to be covered.

"In the engineering school of the University of Missouri a somewhat more careful consideration by the faculty member is required. Three questions are asked each member of the engineering college: First, with reference to each course the instructor is asked to state why engineering students should take the course; second, he is asked to state the specific things that he expects the student to learn to know and to do by taking the course; and, third, he is requested to put down how he proposes to teach the student to know and to do these things. The Oregon Agricultural College has also in the engineering division a similar but somewhat more elaborate method of arriving at information of the same general character. The results of these inquiries are extremely interesting and lead to many important results. Possibly the professional spirit of the faculties in engineering schools which makes them refer to themselves as 'engineers' rather than as 'professors' may account for willingness and industry in promoting such investigation."

Egotistically I have taken pride in my profession, and have always maintained that the best teaching is carried on in engineering schools. I was more than happy to hear Dean Kelly, formerly of the University of Minnesota, now President of the University of South Dakota, and one of the educational experts of the Rockefeller Foundation, make this same statement about three weeks ago in Louisville.

When, however, I read and reread the "Report of the Committee on Admissions and Elimination of Engineering Students," I naturally wonder what sort of teaching must be done in other lines of educational work if our record is as indicated in this report. It is alarming, and we need to take inventory of ourselves when the committee raises the question: "Is it or is it not a correct premise to lay down that nearly every student now entering our engineering colleges is endowed with native ability and enough vocational aptitude to undertake and successfully complete the first two years of college work?"

Since this report was issued, I have changed my opinion. I now believe our teaching methods require an overhauling. My observations also confirm this belief. I have noticed with grave concern the lack of personal interest in the students'

welfare by the faculties and executives. I have noticed with concern the ever-growing demand for more equipment and less instruction. I have noticed with concern the investments in buildings and the lack of investment in teachers. In like manner, an observant person must view with alarm the tendency that Professor Curtis Merriman decries when he states "that teachers are impatient with slow students." Too often, I believe the slow student is unfairly treated. I often wonder what would happen if all the slow students were children of the teachers themselves. I sincerely doubt, then, that the slow student would be a problem.

As a consequence, I am led to make this statement. When the teachers and executives of all schools will bring themselves to consider the students under their charge as their own children, there will no longer be any teaching problems.

Dean James E. Russell of the Teacher's College of Columbia University says, "Leadership in the future will not come by chance. Scientific precision will replace guess-work. Exact knowledge must prevail in high places. Something may be done to improve scholarship in our secondary schools on the part of those who can use it; but the American secondary school has other duties besides the making of scholars. Granting the necessity of scholarship, the heaviest load must be carried by our colleges and universities. They have no need to encourage initiative in thought or action in their students; young Americans exhibit independence enough when left to themselves. But what our students do need is to learn how to study, how to do straightforward logical thinking, how to round out an intellectual task in a scholarly fashion; in a word, they need discipline in learning. The only way to attain this result is straightforward instruction under a master. Desultory teaching with the assignment of tasks to be done at home will not do it. Threats and brow-beating will not do it. University teachers might well learn a lesson from business, where the responsible heads train their subordinates in all kindness, but tolerate no mistakes and permit no guess-work." Master teachers, what a term to conjure with. Are we to let the species die, or shall we aspire to reach that stage?

The day will come; yea, it must come when it will be a privilege to teach. No person is fit to teach, at any time, unless he can put his whole heart into his work.

John Palmer Gavit, in his book "College," says, "The great teacher is not he who tells his students most, but he who by the magic of personal inspiration most thrills them with eagerness to find out for themselves. This is why one *teacher* in a college is worth a dozen 'scholars.' As you go about among colleges, you hear *ad nauseum* about the distinction between them. The controversy is an old one. It is the 'scholars' who display the bitterness. I suspect that a good deal of the bitterness arises out of a guilty conscience. It is a good deal of trouble to teach if you don't love young people."

It is my opinion that the man or woman who attempts to teach merely because it is a "scholarly vocation" is a parasite to any educational institution. "If the instructor of any grade," says Gavit, "holds the medieval idea that education is the prerogative of a caste and resents the invasion of a horde of ordinary youth of all sorts, he may still be in some sense a profound scholar, but he will not do much *teaching*. If he views the students either socially or intellectually as beneath his condescending contempt; if he resents and despises hand-to-hand contact with them as an interference with his work as a researcher or author, or as in some way derogatory of his dignity as a scholar; he will not get far with students."

As a student I have been forced in contact with this type; I have dozed in the classes of such; I have been snubbed; and I have felt the contempt with which they abound. And as a teacher, I have been associated with them; I have been criticized by them because I failed to "uphold the dignity of the profession" when I remained after hours to give aid.

It is my observation, gleaned by contact, that the besetting sin of our institutions is that there is by far too much "lecturing" and "giving of courses" in place of simple face-to-face teaching.

There is no doubt that lecturing is easier. A teacher can prepare a "course" and keep it up-to-date, and "from his pedestal drop it down on his students' heads." Not so with

teaching; "the personal contacts" require him to keep awake. Hence to the common-place question "why don't the professors get closer to their students?", Gavit bluntly, and I think, truthfully answers, "They don't want to; it is too much trouble."

"Education," James says, "is the influencing of man by man, and has for its end to *lead* him to actualize himself through his own efforts." The real teacher is the influencing agent of whom James speaks; he is the leader who makes it possible for the student to actualize himself, not the lecturer. The teacher is the gardener who digs about and nourishes the plant which grows of its own impulse. His function is not to make pupils learn, but to make learning attractive. To do this requires effort, interest, and a heart filled with love for the youth entrusted to his care."

My opinions and observations on teaching are best expressed when I say "Let us emulate the Great Teacher who taught, led, and died, so that we would live."

THE RELATIONSHIP OF RESEARCH TO GRADUATE AND UNDERGRADUATE INSTRUCTION IN ENGINEERING *

By L. S. O'BANNON
University of Kentucky

Engineering research in a technical institution may be divided into two classes. The first includes work which is sponsored and supported by manufacturers and associations exterior to the organization of the technical institution. The second class includes work sponsored by the institution itself, through the personal interest of the members of the institutional staff. There is, of course, the crisscross combination of these two classes: an inspired individual on the staff may seek the aid of industry; or industry may seek the aid of a staff member having a special interest in the particular problem demanding research.

In doing research of the first class, the facilities of the university become a convenience for the company, the association, the corporation, the state or whatever organization is to benefit directly by the results. The members of the research staff become virtually hired technicians.

Research of this type becomes almost a business with the institution in some departments, and frequently overshadows the instructional function of the departments. Such departments usually have a corps of assistants whose duties consist of the routine of research. These assistants seldom come into contact with the students. In a good many instances the assistants are graduate students working for higher degrees. Research of this kind is likely to become very much commercialized. The heads-of-staff practically occupy the position of consulting engineers. Manufacturers quite often are influenced by their choice of a particular laboratory by the

* Presented at a meeting of the Kentucky Section of the Society.

personnel at the head of the laboratory, so that the results of the research may bear the stamp of recognized authority. In very rare cases is the institution repaid in full in a monetary way for the service rendered. The support given by the manufacturer rarely equals the cost of material and assistance. Overhead, including money invested in stationary equipment, instruments and scientific apparatus, is seldom, if ever, charged to the project.

It is exceedingly doubtful whether research of this type reflects to the advantage of the institution in proportion to the time, money and effort put in to it. A certain amount of prestige may be gained through publication and dissemination of the results, especially if an appreciable amount of good reflects to the general public. More often the greatest credit is received by some individual member of the staff. The person's reputation grows, his salary grows, and finally, the institution may become the loser through his transfer to some other institution, either educational or industrial, or through his going into business for himself. When we keep in mind the principal purpose of the university, which is the educational development of the students coming within its walls, it is hard to justify any extensive program of research in which commercialism plays the larger part and industry derives the greater benefits.

The second class of research is that which originates within the institution through personal interest on the part of members of the staff. The problem grows with the investigator and the investigator grows with the problem. It may become creative work of the highest order. There is no time limit. There is no one urging completion of a report, which sometimes results in skimping and the formation of premature conclusions.

This kind of research affects directly the personality of the investigator and every one coming into contact with him. It calls forth the good qualities which we daily try to instill into our students: enthusiasm, initiative, originality, constant application, intensity of effort, attention to details, scientific judgment, an humble attitude, respect for learning; and a

host of other qualities upon which we can all elaborate. There comes the thrill of discovery; the satisfaction of having completed something worthwhile; and not infrequently, public recognition and the flattery of friends.

What are the opportunities for this kind of research? They are, of course, great; but the engineering schools occupy a peculiar position in this respect as compared with other fields. The engineering schools train men primarily for industrial organizations. A relatively small number might be considered as being trained directly for public service. Industry perhaps more than any other organization in society has recognized the value of research and has practiced it both intensively and extensively. Numerous manufacturing and industrial establishments have their own research laboratories and give them generous support. They are more or less independent of outside scientific skill. When a manufacturer calls on a university for research it is because of the temporary nature of the work, and the manufacturer's unwillingness from an economic point of view to make the necessary investment to keep the work at home.

We can see in agriculture a contrasting example. Outside of the state and federal supported agricultural experiment stations there are very few laboratories doing scientific research in this field. The agricultural experiment stations in connection with the agricultural colleges conceive, initiate and carry out practically all the research projects ensuing to the benefit of agriculture. On the other hand, engineering research occupies a minor place in connection with engineering schools because institutional engineering research occupies a minor place in industry.

If this is true, is it also true that collegiate engineering research plays a minor part in graduate and undergraduate instruction? I believe it does. Research (of the right sort) in a university is an obligation imposed by virtue of the unique position which the university occupies, in that it affords superior facilities, and a superior personnel, dedicated to the best interests of mankind. Every educational institution of university grade *should* provide not only the oppor-

tunity but also the facilities for carrying on research. Every person on the teaching staff should be permitted and urged to exercise his own innate urge to seek further into the unknown; theoretically, without restraint, but practically, some restraint may be necessary. For instance, a state university should keep in mind its obligation to the state. The large problems of engineering research should pertain to the development of the material resources of the state; and to industrial problems, from the solution of which the mass of the people are to derive the greatest good. Similarly a municipal university should keep paramount its obligation to serve the municipality. This is an economic, geographical, political obligation. After that comes the possibility of unselfish service to all mankind.

If it were practical, or even possible, to train our undergraduates by some kind of system of first hand experience, it would be both desirable and effective. But this is totally impossible. Our students come to the university to learn by short experience the long experience of others. We can not reproduce the past for their benefit; they can only review the past historically. The laboratory exercises are designed to reenact the discovery of basic principles and represent the best we can do to conjure up the past. Undergraduate theses involving experimental work are little more than extensions of the laboratory work. The benefits derived by the student through preparation and completion of his thesis are undoubtedly of considerable value. On the other hand, continuation of class room work over the same period as is ordinarily given up to thesis work may be of *greater* value. If research is to be of the greatest personal benefit it must be indulged in. Second hand contact with research may be influential and beneficial to a degree but it is a small degree at most.

If we assume that the graduate student's curriculum includes a research problem for his thesis, we can dismiss the difference between his case and the undergraduate's, by saying that the benefits he derives are greater and the influences more intense on account of his immediate contact with the

problem. He is in contact with those subtle influences which develop those good qualities of enthusiasm, etc., which we have already mentioned.

If it were practical to make every student a responsible head or an original investigator of a research problem there is no question but what this would be a valuable element in his training. However, this is entirely impractical; and even if it were not, the time consumed in carrying out such a project might be spent more profitably in learning the fundamental discoveries of the past through the established mechanism already provided by the university for that purpose.

To keep to the topic of our discussion, we must assume that engineering research is to be a part of the institution's activities, and furthermore, we will assume that the work will be under the responsible direction of the teaching staff. What, then, is the relationship between research and student instruction?

In the first place, the relation is slight. There is a tendency to conduct research more for its own sake than for the influence it may have on instruction. Next, the direct value accruing to the student is proportional to the amount of his activity in connection with the research problem. This also is slight. While it is true that a limited number of students may be used as assistants on a research problem, it is seldom that the student is given enough responsibility, or sufficiently comprehends the problem, or shows enough intelligent interest, to acquire very many, or very much of those intangible inspirational qualities which abide in the author of the project. The student acquires very little more of the scientific method employed. The new facts discovered usually have slight utility value for the student.

Finally, and this is most important, the relationship between research and instruction is the same relationship that exists between student and teacher. The value for instructional purposes will depend upon how the research is reflected through the teacher to the student. We can readily see, without going into the details, how the connection between student and teacher may be modified due to the teach-

er's interest in a live problem of research. There may be the increased respect given the teacher due to his becoming a recognized authority in some specialized field. There may be added prestige due to his authorship of scientific papers and of textbooks. There is the opportunity of lively discussion of a live problem in the class room. There is the opportunity for the student to catch some of the enthusiasm and the inspiration of the research worker. There is the up-to-date, before-the-press information of material facts which may pass from teacher to student. There is in short the opportunity given the student to live and indulge in the experience of a contemporary, relieving the student somewhat of the monotony of historical facts and "deadness" found in his textbook.

But there is another right pertinent objection which may be raised here. Research takes time. Any teacher dealing with a research problem is likely to have his mind on the problem more often than on his students. It is more probable that a teacher could spend all of his time on teaching with better effectiveness in his instruction, than would be obtained if he divided his time between teaching and research.

ENGINEERING SCHOOLS AND THE CHANGING TIMES

WARREN D. GARMAN, *Assistant Professor of Mechanical Engineering*, Bucknell University

The article on the "Purpose and Scope of Shop Courses," written by Professor O. W. Boston, which appeared in a recent issue of THE JOURNAL, was timely and interesting. Coming from one who is closely associated with the shop work, as it is taught in one of the larger universities, the opinions expressed by the author are especially valuable to all who are desirous of teaching only the essential subjects to the college student. Of particular interest was the point brought out that the actual manual work should occupy the least possible time while the majority of the time should be given over to lectures, quizzes, etc. This statement and the fact that the development of manual skill should not be the aim of the college shop courses are full of significance, and it is on these points that the writer begs leave to enlarge.

Early in the article referred to the author points out the difference between the course offered to the dental students and that given to the engineering students. In the former manual skill is emphasized while in the latter the demonstration of principle holds first place. This is as it should be, for the dentist's success rests largely on his ability to use his hands in his laboratory, which consists of both his "back" office and his adjoining work room. In comparison it might be said that the engineer's laboratory consists of the pattern shop, foundry, forge shop, machine shop, pressed metal and metallurgical departments, etc., etc., and it has grown so large that it is physically impossible for him to master the manual skill needed to produce real service. Hence he must be content to plan and to manage rather than to do the actual work with his hands. This is so evident that we wonder why some of our colleges, especially the small engineering schools, still aim at manual skill. Or, to put the question more

broadly, we wonder why any of our engineering schools have shop courses in which the engineering student is required to operate machines.

The foregoing statement, or query, provokes the following questions.

1. Were engineering colleges ever justified in giving shop courses in which the attainment of manual skill was paramount?

2. Are engineering colleges justified at this time in giving shop courses in which the engineering students are required to perform certain operations on the machines?

3. What type of shop courses should the engineering colleges give?

In an attempt to obtain an answer to the first question let us make a hasty review of the relation of engineering to the sciences from which it sprung and also of the early history of engineering. This will give us an idea of the age of the art and tell us something of its probable effect upon the young engineering schools. In order to conserve space and time only a few instances will be cited; others can easily be recalled by the reader.

From the standpoint of industrial history engineering is a comparatively young art although the sciences which lead up to it are, in some cases, quite old. The study of electricity as a science may be said to date back to 600 B.C., when Thales told of the charge that may be produced on amber when rubbed, but only recently we celebrated the fiftieth anniversary of the invention of the incandescent light, and the first electric generator is only a few years older. The science underlying the heat engine may be said to have started with Hero about 130 B.C., when he described his reaction turbine, but the first commercially successful heat engine was built by Newcomen in 1705, and James Watt did his notable work after 1763. It was Watt's work that really ushered in the machine age and gave birth to mechanical engineering. Chemical engineering is a product of the last century while chemistry as a science may be traced back to the listing of the elements by the early Hindus and Chinese. Civil engineer-

ing is older than any of the other engineering arts, but as civil engineering students are not required to take up shop courses to the extent demanded of other engineering students that particular branch of engineering need not be considered here.

It is hoped that the above brief sketch will emphasize the fact that engineering is in the early stages of its growth and therefore the engineers of only a few generations ago had little to guide them. For that reason the early engineers were builders and mechanics who depended upon experimental methods almost entirely for their guidance as there was little theory for them to use. Watt built engines in the latter part of the eighteenth century and in the early part of the nineteenth century they were adapted to railroad and steamboat transportation as well as to the manufacturing plants, but it was not until 1824 that Carnot made it possible to apply the law of the conservation of energy to the transformation of heat energy into mechanical energy. And in 1849 Joule established a value for the mechanical equivalent of heat. Of course much had been done in the way of calorimetry and thermometry before this, but the study of heat had not reached a state that was applicable to the real development of the heat engine until after the work of Carnot, Rankine, and others of the nineteenth century. Similar pictures can be drawn of the early stages of electrical and chemical engineering; all going to show that the early conception of the engineer was that of a mechanic. He was versed in the small amount of theory relating directly to the mechanism he was building, to be sure; but above all, he could often execute the manual tasks as proficiently as any of his associates. Hence early engineering schools aimed to turn out men of that caliber, and a high ambition it was, considering the type of men who were the pioneers of our profession.

At that time the shops held a very important place in the curriculum of the college, and there were schools that included shop work throughout the entire four years. It was then that the students built small steam and gas engines, the construction of which required much extra time in addition

to the regular requirement. The students were justly proud of their work and many successful men were graduated from the schools, as we know. Production methods in the machine shops and foundries and many processes now used were not known at that time. In fact it was not until 1861 that Mr. Joseph R. Brown invented the universal milling machine, the principle of which forms the backbone of most production machinery, and only slightly more than ten years ago continuous pouring and conveyor systems came into general use in the larger gray-iron foundries. Then a machinist was a machinist: later he became known as "an all-around man" to distinguish him from the specialists who came into being with the production methods. Therefore, a course in shop practice in the early engineering schools could not have been much more than a course in manual training.

The fact that methods in shop practice persist in the colleges after they are more or less obsolete in the industries is to be expected when we consider the cost of equipment. The best way to eliminate that handicap is to teach without the equipment when such a course is plausible.

And now in order to obtain an answer to the second question let us turn our attention to the progress made in engineering during the latter part of the nineteenth century and to the present date in the twentieth century. We see the refinement of the steam reciprocating engine, the development of the steam turbine, and the remarkable advances made in the construction of steam boilers. These forward steps, together with the tendency toward higher steam pressures, require of the engineer a thorough knowledge of several branches of engineering, which need not be mentioned. The old single-cylinder, slow moving, jerky automobile has grown into a four, six, eight, or sixteen cylinder fleet moving, smooth running car ranging from the two-passenger roadster to the large bus and the powerful trucks and vans. The air-plane has passed from the experimental phase and has become an important factor in transportation. Because of the refinement demanded in these two developments alone the engineer is confronted with weighty problems in thermodynamics,

strength of materials, metallurgy, aerodynamics, and dynamic balancing. The means of communication have passed from the comparatively simple telegraph instrument and the clumsy telephone to the more complicated instruments and systems capable of handling many messages at the same time over long distances. These, together with the wireless telegraphy and radio, present problems that challenge the ability of the best engineers. There is no need to add to the list of achievements in engineering, although many more could be added, for enough has been said to answer the present purpose.

The point to be brought out in the above citation is that the many fields of engineering have broadened to such an extent during the last few decades that the engineer has been forced to relinquish his grip on the trades in favor of a better understanding of the theory. Even in the small plants the engineer's success, and consequently that of the plant, does not depend upon his ability as a machinist, foundryman, or blacksmith, etc. To be sure a good acquaintance with shop practice is usually desirable but the actual performance is left to the men who have specialized in the different branches of the work.

The answer to the second question seems to be that the engineering student should not be called upon to spend any time in attempting to do the work of the tradesman unless such work is of immediate benefit to him. It does not seem likely that any such benefit can be expected because the operations that the student is ordinarily required to perform are so elementary that it is doubtful whether their actual performance is necessary in order that he can fully understand them.

Naturally the question arises as to how the young engineer will obtain his knowledge of shop practice and who will supervise that part of his training. The writer feels that the practical training should be left to the industries while the theoretical training should be taken care of by the engineering schools. It has been pointed out that the amount of theory needed to understand fully and solve the problems with which the engineer comes into contact has greatly increased within the last few decades. Four school years is indeed a short

time in which to give the student the foundation he should have in order to cope with these problems. A great deal of experience in mathematics and physics is required in addition to the specialized training he should receive in the engineering courses proper. For these reasons the student should be given lectures in shop practice only to the extent that is absolutely necessary for him to understand the related work in design and management. The industries are not only in a better position than the schools to acquaint the young engineer with actual shop practice, but they have signified their willingness and desire to do so by the many continuation courses which they give to the graduates they employ.

In closing it may be said that the technique desirable for the engineer will be acquired in the physics and experimental engineering laboratories. In these laboratories much use is made of the principles studied, and the qualities needed by the engineer are developed to a greater extent than is possible in the average college shops.

NEW MEMBERS

BEECKEL, HERMANN C., Instructor in Civil Engineering, Union College, Schenectady, N. Y. John Macdonald, W. C. Taylor.

BRADLEY, HARRY C., Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass. H. W. Tyler, E. F. Watts.

COMPTON, KARL T., Professor of Physics, Princeton University, Princeton, N. J. A. M. Greene, Jr., Geo. B. Pegram.

DOWNING, LEWIS K., Associate Professor of Civil Engineering, Howard University, Washington, D. C. H. D. Hatfield, D. Howard.

FERGUSON, PHIL M., Associate Professor of Civil Engineering, University of Texas, Austin, Tex. T. U. Taylor, E. C. H. Bantel.

GOODRICH, ARTHUR L., Associate Professor of Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass. Earl F. Watts, H. W. Tyler.

HARDGRAVE, JOHN C., Instructor in Mechanical Engineering, Superintendent of Shops, Texas Technological College, Lubbock, Texas. Carl L. Svensen, S. J. Boller.

HELWIG, WILLIAM F., Assistant Professor of Electrical Engineering, Texas Technological College, Lubbock, Texas. Carl L. Svensen, S. J. Boller.

JONES, LAWRENCE D., Assistant Professor of Engineering Drawing, Secretary, College of Engineering, The Ohio State University, Columbus, Ohio. Thos. E. French, Chas. D. Cooper.

LEHOCZKY, PAUL N., Instructor in Industrial Engineering, The Ohio State University, Columbus, O. John Younger, E. A. Hitchcock.

MILLER, JOHN M., Instructor in Engineering, The Rice Institute, Houston, Texas. H. K. Humphrey, Wm. E. White.

MORRIS, HUBERT M., General Employment and Safety Supervisor, The Bell Telephone Company of Canada, W. A., Toronto, Ont. L. St. J. Haskell, C. H. Mitchell.

NORMAN, ROY A., Professor of Mechanical Engineering, Iowa State College, Ames, Iowa. W. H. Meeker, A. H. Fuller.

TOBIAS, ARTHUR L., Instructor in Engineering Drawing, The Pennsylvania State College, State College, Pa. O. K. Harlan, C. G. Gaum.

WEISS, HERBERT A., Assistant Professor of Mechanical Engineering, Clarkson College of Technology, Potsdam, N. Y. J. E. Rowe, J. A. Ross, Jr.

WILSON, FREDERICK C., Dean of Engineering, Professor of Civil Engineering, Clarkson College of Technology, Potsdam, N. Y. John A. Kerr, Jr., Jos. E. Rowe.

200 new members this year.

THE FIRST INTERNATIONAL CONFERENCE ON THE TEACHING OF ENGLISH TO ENGINEERING STUDENTS

The Committee on English announces the eighth conference on the teaching of English to be held in connection with the annual meeting of the S. P. E. E., at Montreal, June 26 to 28. As this will be the first meeting to be held in Canada, it affords a rare opportunity to bring together the teachers of English from both American and Canadian schools for the discussion of their common problems. The occasion is so full of possibilities that the Committee is announcing it as "The First International Conference on the Teaching of English to Engineering Students." This may be a bit pretentious in its phrasing but it indicates how much importance the Committee attaches to this meeting. These conferences, initiated at the annual meeting of the Society at the University of Illinois, eight years ago, have had a real effect, it is believed, on the development of English teaching in the engineering colleges and have been influential in gaining a fuller recognition of the important place of English in the training of engineering and technical students. The present conference affords a wonderful opportunity for the exchange of ideas between the teachers of the neighbor countries. In addition to the formal session announced for Thursday morning, there will be at least one informal conference, and as usual the open meetings of the Committee for the more intimate and personal discussion of teaching problems.

The Committee on English:

SADA A. HARBARGER, *Chairman*, The Ohio State University,
J. RALEIGH NELSON, University of Michigan,
W. OTTO BIRK, University of Colorado,
H. G. PEARSON, Massachusetts Institute of Technology,
H. C. RICHARDSON, University of Minnesota,
H. L. CREEK, Purdue University.

OBITUARY

Arthur H. Ford was born in Chicago, February 6, 1874, where he resided until the time that he took up his professional work. He attended the University of Wisconsin and received his B.S. in E.E. in 1895. He remained at Wisconsin one more year, having a Fellowship in Electrical Engineering. At the end of this period he received his professional degree. He then went to Columbia University and took advanced work in his hobby—that of illumination.

He began his technical work as an apprentice engineer with the General Electric Co. in 1899. In 1900 he was an engineer on the staff of the Western Electric Co. At this point in his career he turned to engineering education and this he was interested in until his death. He was acting Professor of Electrical Engineering at University of Colorado in 1900–1901; Professor of Electrical Engineering at the Georgia School of Technology from 1901–1905. From there he went to Iowa as the head of the Electrical Engineering department which he practically built from its infancy.

His consulting work brought him in contact with several large corporations. He was a Director and Illuminating Engineer for the Totalux Co. He was the inventor of glareless auto headlights, a devise that is being used to a great extent by all automotive Engineers.

Professor Ford has been a member of this Society since 1903.

SECTIONS AND BRANCHES

The **Middle Atlantic Section** of the Society held their Fall meeting at the Bell Telephone Laboratories, New York City, on December 14, 1929.

The meeting was preceded by an extremely interesting inspection trip through the Laboratories, followed by a luncheon and inspection at the Long Lines Dept. of the N. Y. Telephone Co. at Walker Street.

The afternoon session was held in the Auditorium of the Bell Laboratories with Professor H. P. Hammond presiding.

The program was as follows:

"Welcome to Bell Telephone Laboratories." By H. P. Charlesworth, Vice President.

"The Teaching of the Economics of Engineering." By William D. Ennis, Alexander Crombie Humphreys Professor of Economics of Engineering, Stevens Institute of Technology.

"Engineering Education in Great Britain." By Bernard Hague, Visiting Professor of Electrical Engineering, Polytechnic Institute of Brooklyn; Senior Lecturer in Electrical Engineering, University of Glasgow.

"Education Program of Bell Telephone Laboratories." By George B. Thomas, Personnel Director.

Dinner was served at six in the restaurant after which the members again adjourned to the auditorium.

A short business meeting was held with Professor H. P. Hammond presiding.

Moved, seconded, and carried that it be the sense of the meeting that the practice of the New England section with regard to dinner be adopted, viz., that the school acting as host may serve a complimentary buffet luncheon at noon if they so desire but that the dinner may be paid for by the members attending.

President Richards invited the Society to hold their Spring

meeting at Lehigh University, and the invitation was duly accepted.

The Nominating Committee, composed of Professor H. S. Edwards of Pratt Institute, Professor H. C. Berry of the University of Pennsylvania, and Professor E. F. Church, Jr., of Brooklyn Polytechnic Institute, presented the names of President C. R. Richards of Lehigh for chairman and Professor C. P. Bliss of New York University, for secretary of the section. The committee's report was accepted and the nominees were unanimously elected.

The Committee on Resolutions, composed of Professor F. L. Eidmann of Princeton, W. A. Curry of Columbia, and J. W. Barker of Lehigh University, submitted the following report which was unanimously adopted:

It is the desire of the Middle Atlantic Section of the Society for the Promotion of Engineering Education to express its thanks and appreciation to the officials of the Bell System, the Bell Telephone Laboratories, and the Long Lines Department of American Telephone and Telegraph Company and in particular to Messrs. H. P. Charlesworth, George B. Thomas and L. S. Crosby and their associates, for arranging the very interesting and instructive inspection trips and programs of the day, and for the very cordial, generous and gracious hospitality extended to our group. We wish, also, to express our thanks to Dr. Ives for his lecture and remarkable demonstration of colored television, to Dr. F. L. Hunt for his demonstration of talking motion pictures, to the other speakers and to all who have contributed in any way toward the success of today's meeting; and it is moved that this resolution be adopted by a rising vote of thanks and that the secretary be instructed to spread a copy thereof on the minutes of the meeting.

Respectfully submitted,
J. W. Barker,
W. A. Curry,
F. L. Eidmann, *Chairman.*

The evening program followed. This included a special demonstration of talking pictures in which the officers of the section were the actors. In addition to this very entertaining feature reels showing the application of the talking pic-

tures to educational lectures were shown. These special pictures were made under the direction of Dr. F. L. Hunt of the Bell Laboratories, who gave an explanation of the work being done in this field.

Dr. Herbert E. Ives gave a short lecture explaining the system of color television which he had developed and the Society was honored with the first public demonstration of this development.

The speakers of the evening were: C. R. Richards, President, Lehigh University; F. L. Bishop, Secretary of the Society for the Promotion of Engineering Education; R. I. Rees, President, Society for the Promotion of Engineering Education.

The meeting was attended by 225 members and guests who all agreed that it was a most pleasant and instructive meeting.

FRED H. PUMPHREY,
Secretary pro tem.

COLLEGE NOTES

Polytechnic Institute of Brooklyn will celebrate the completion of its seventy-fifth year on June 17 and 18. An anniversary dinner under the auspices of the Corporation, Faculty, and Alumni will be held at the St. George Hotel in Brooklyn on the evening of the 17th. Among the speakers will be Mr. Walter Hampden, Polytechnic, 1900; Dr. Frank Graves, Commissioner of Education of the State of New York, and Professor Karl Compton of Princeton University, President-elect of the Massachusetts Institute of Technology.

The seventy-fifth annual commencement will be held on June 18 with Dr. Graves as commencement speaker. First honorary degrees in the history of the Institute will be conferred on Admiral Richard E. Byrd and Professor Karl Compton. Polytechnic Institute of Brooklyn is one of the oldest American colleges of Engineering and is a pioneer in the establishment of college grade evening courses leading to the degree. Recently the Polytechnic has extended courses into the field of graduate work for the master's degree, more than 200 graduate engineers being thus enrolled.

Clyde C. Whipple, Assistant Professor of Electrical Engineering at the Polytechnic Institute of Brooklyn, has been granted leave of absence for one year by the Corporation of the Institute to serve as visiting professor in electrical engineering at the Green School of Engineering of Princeton University.

Colorado School of Mines.—Commencement was held May 16, at which time sixty-seven degrees were conferred in Mining, Metallurgy, Geology and Petroleum.

The Curriculum Committee at the Colorado School of Mines has just completed its work on the revision of the curriculum. No radical changes were made but a much closer correlation of courses was effected in the different departments.

The courses in the Geophysics department have been revised and enlarged. Much new apparatus has been added to the department and both theoretical and practical work is being given in magnetic, electrical, and radioactive prospecting, also courses in torsion balance, seismograph and geothermo investigations are offered as well as general geophysical methods.

Magnetic prospecting includes fundamental principles of magnetic fields, the magnetic field of the earth and its constituents; magnetization of rocks and its determination; derivation of universal theory of magnetic instruments; description of the most important types of magnetometers; effects of magnetized bodies; methods of interpretation; discussion of magnetometer results; relation between magnetic and gravitational anomalies, also practice in observation of horizontal and vertical magnetometers, Schmidt type, dip needle practice, observations with the rotary inclinator, determination of scale values, magnetic moments and temperature coefficients of horizontal and vertical magnetometers and of magnets. Qualitative determinations of the magnetic properties of rocks; organization of field work.

In electrical prospecting there is given a classification of electrical methods; Elementary theory of electrical field; Principles of the electromagnetic field and electromagnetic induction; Electric properties of rocks and their determination; Natural earth currents and their measurements, self-potential of ore bodies and its determination.

The lectures in radioactive prospecting include fundamental principles of radioactivity of matter, atomic theory; radioactive transformations and radiations; instruments and methods used for the determination of radioactivity of substances; methods of radioactive prospecting; results obtained; applications of method.

The courses in torsion balance, seismograph, and magnetometer have been extended both in theory and practice.

Massachusetts Institute of Technology.—The following Japanese professors have been observing the teaching methods

of the Department of Chemical Engineering during the past two years:

Hatta, Sirozi; Asst. Prof. Chemical Technological Institute. Tokio Imperial University, Sendai, Japan.

Kamei, Saburo; Asst. Prof. Kioto Imperial College.

Okamura, Sakio; Prof. Yokohama Technical College.

Uchida, Shun-Ichi; Asst. Prof. of Applied Chemistry, Tokio Higher Technical College.

BOOK REVIEWS

Work Routing in Production. JOHN YOUNGER. Published by The Ronald Press Company. 1930. 115 pages. $2.50.

The purpose of this book, as expressed in the preface, is to develop the underlying principles governing three of the steps in production control: work routing, scheduling and dispatching. The author has succeeded admirably in attaining his purpose and this should be an excellent book for use as a text for industrial engineering students and as a reference book for production executives.

Notably concise in his presentation, the author emphasizes and clarifies his points by numerous and pertinent examples from actual practice. There are well selected problems at the end of each chapter, and there is also a list of questions at the end of the book covering points of special importance. The charts and the photographs showing industrial processes are very good.

The reviewer found Chapter V, on the economic size of production lot, the only part of the book where the presentation was not absolutely clear. This, of course, is no particular disadvantage in class use where the instructor can clear up any difficulties the students may have.

P. T. N., JR.

Mechanics of the Gyroscope. RICHARD F. DEIMEL. MacMillan, 1929. 192 pages. $4.00.

"Some books" wrote Bacon, "are to be chewed and digested." This dictum applies with considerable force to Professor Deimel's scholarly work on the gyroscope.

In the opening chapters the author gives a brief but rigorous and highly mathematical review of the fundamentals of plane motion, motion in space and laws of dynamics which are applicable to gyroscopic problems. On this basis the author builds his discussion of the action of simple gyroscopes,

the top, spinning disks, the gyro compass, stabilizers, automatic steering devices, etc.

The book may be highly recommended to the mathematically-minded student who is interested in gyroscopic phenomena. Others are advised to avoid it. It must be carefully "chewed" and thoroughly "digested" in order to obtain any nourishment from it. It is safe to say that the average undergraduate—at least in the schools with which the reviewer has been connected—will find it a tough morsel. For the reader whose teeth and digestion are equal to the task it will prove a stimulating and highly profitable study.

J. A. D.

Alternating Currents for Technical Students. CALVIN C. BISHOP, Technical High School, Buffalo. 312 pages; 13 chapters. D. Van Nostrand Company.

The author has covered the fundamentals of alternating currents in elementary, understandable language using the minimum of mathematics. The book includes circuits, vectors, machinery and other special A.C. apparatus. The treatment of machinery leans to the practical point of view rather than the designer problems, although fundamental reasons for certain characteristics are included in many cases. Problems and questions at the end of each chapter provide an opportunity for the student to clinch the fundamentals in that chapter.

Chapter XII is intended for laboratory use. Twenty-three of the most common tests are suggested for the students' further study of the subject of alternating current circuits and machinery.

Chapter XIII includes Trigonometry used in A.C. work together with a one-page four-place table of natural functions.

The book should find application in non-electrical courses and in some night school work where endeavors are being made to give Engineering training of a University calibre.

R. C. G.

Materials of Engineering Construction. FRANCIS W. ROYS. Ronald Press Company. 331 pages. Price $4.00.

This book is intended for use "as a text for the student of engineering, to enable him to obtain a close acquaintance with the characteristics and properties of the more common and most widely used materials of engineering." At the same time it contains much information of a type and so arranged to make it a valuable reference text for the practicing engineer.

In the first chapter, the author reviews briefly but comprehensively some of the definitions and concepts fundamental to the subject. In later chapters he takes up in clear, concise and logical style many topics not ordinarily treated in a text on this subject. In fact, it is difficult to find in standard handbooks much of the data given. The chapter headings include:

Wood for Structural Purposes.
Lime and Plaster.
Hydraulic Cements and Concretes.
Structural Clay Products.
Building Stone.
Ferrous Metals.
Non-ferrous Metals and Alloys.
Corrosion of Metals.
Temperature Effects on Metals.
Failure of Material under Repeated Stress.
Varnishes and Paints.

The book is profusely illustrated. There are 167 diagrams and illustrations and 17 tables. At the close of each chapter, well selected references on the topic covered are listed. The make-up of the book is unusually good. It should filll a real need as a text and as a reference book.

J. W. H.